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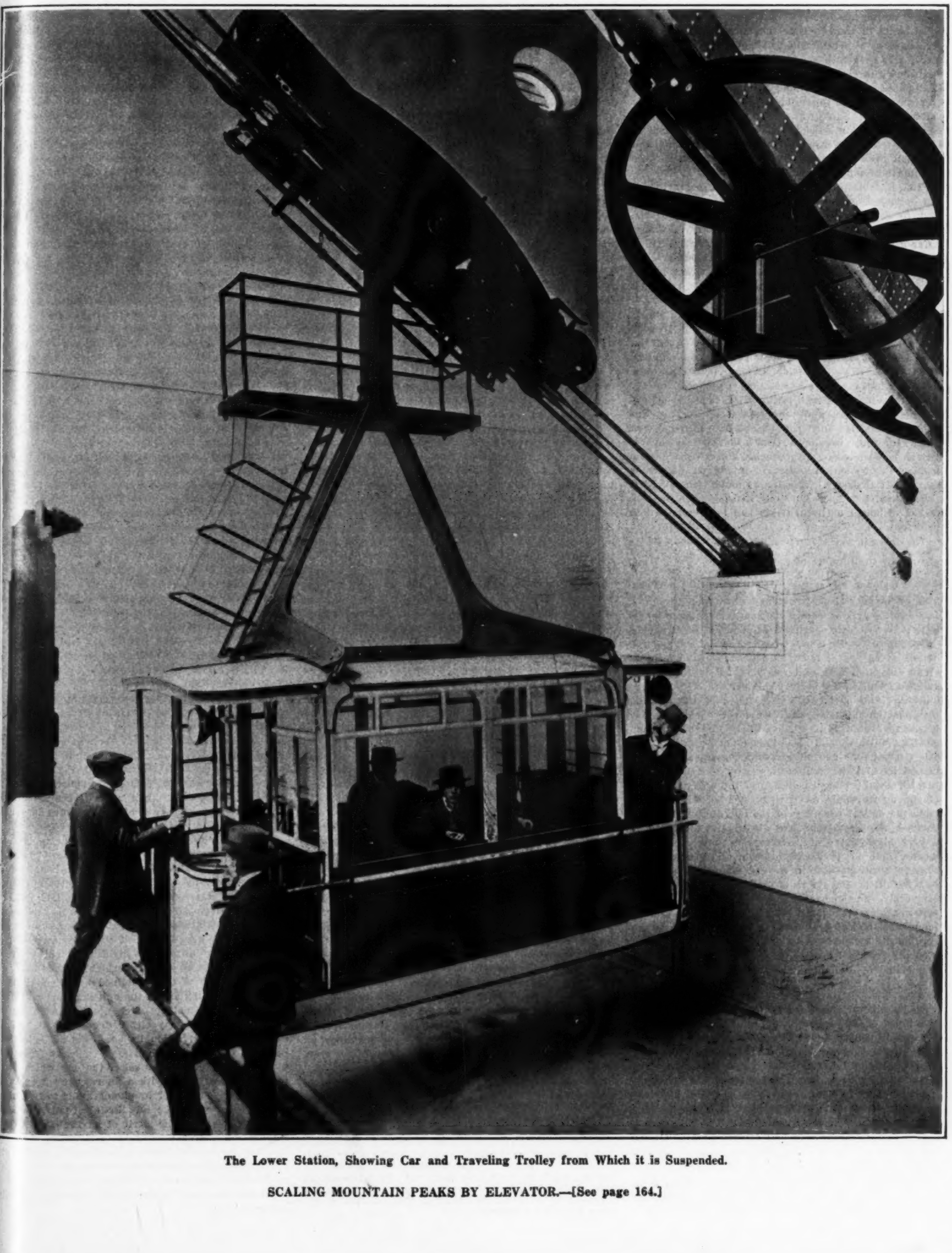


The Lower Station, Showing Car and Traveling Trolley from Which it is Suspended.

SCALING MOUNTAIN PEAKS BY ELEVATOR.—[See page 164.]

Modern Microscopical Optics*

The Limitations of the Microscope

By C. Metz

Gauss's theory of lenses and other optical systems, which was published in 1840 in his "Dioptrische Untersuchungen," and subsequently largely extended by many other investigators, rendered it possible to apply the cardinal theorems relating to the formation of optical images to the most complicated systems of lenses, of which even in Gauss's time the microscope objectives furnished a good example. This theory paved the way for the computation of microscopic objectives and furnished a means of studying the optical principles of the microscope as a whole and the objective and eyepiece considered separately.

Even before Gauss, Fraunhofer in 1820 had succeeded in devising a complete system, enabling him to compute telescope lenses, and a little later Seidel and Steinheil evolved a similarly complete system for the computation of photographic lenses.

Prof. E. Abbe, who in 1866 became associated with the optical establishment of Carl Zeiss in Jena, was first to venture upon a complete calculation of the microscope objective by applying the theory of Gauss. After a series of futile attempts, he established a system by which a microscope objective could be computed in every detail. The methods by which he applied his system to practical computations have not been made known.

A further valuable contribution to practical optics was made by Helmholtz and Abbe, who, by discovering the sine condition, showed the means by which an object and its image can be made geometrically similar. It is, however, a great mistake to suppose that these achievements in the mathematical equipment of the microscope inaugurated a brilliant epoch in the history of the microscope, and that enormous progress was made henceforth. In the first place, it was found that by a carefully developed trial-and-error system opticians had succeeded in producing objectives which in a high degree satisfied the conditions postulated by mathematical theory. Thus it was found that all objectives tested by Abbe completely satisfied the sine condition, although until then this had been unknown in principle.

The investigations of Helmholtz and Abbe (1874) showed by the formula of the former, $\epsilon = \frac{\lambda}{2 \sin \alpha}$ and Abbe's formula, $\epsilon = \frac{\lambda}{2n \sin \alpha}$, that the optical performance of the microscope is confined within definite limits. In these formulæ ϵ denotes the smallest distance separating two successive particles of an object which can be differentiated under a microscope; λ is the wave length of any given ray of light, as defined by Helmholtz, in air or any other medium intervening between the object and the front lens; α is the semi-apertural angle[1] of the objective, and n the refractive index of the medium between the objective and the cover glass. In dry lenses the value of n is accordingly 1.0, in water-immersion it is 1.33, and in oil-immersion lenses $n = 1.52$. The denominator in Abbe's formula, $n \sin \alpha$, has been named by him the numerical aperture of the lens; it furnishes the principal criterion of the optical capacity of the microscope. When these factors, which determine the optical resources of the microscope, were discovered, the microscope had already been brought to a very high degree of perfection by purely empirical means, and in practical respects the formula had already been satisfied to a very considerable extent, and but little scope was left to the investigator and computor. The apertural angle had already attained very considerable magnitudes; water-immersion and oil-immersion lenses were already in existence, and accordingly the element n in Abbe's formula had already received practical consideration, while in the formula enunciated by Helmholtz the wave length of a ray in air had become reduced to a quotient $\frac{\lambda}{n}$, by which the wave-length was shortened in proportion to the refractive index of the medium.

Amici in Italy, Spencer in America, Fraunhofer, Kellner, Oberhauser, and Hartnack in Germany, Chevalier in France, and Ross and Powell and Lealand in England had all done a great deal to perfect the microscope objective. In medical research a new era had been inaugurated by the achievements of microscopic observations; histology and pathology had been placed upon a firm basis; and Pasteur had already planted the beginnings of bacteriology and identified a number of pathogenic germs. In the face of the difficulties and limited possibilities with which the optician had to contend, it would be interesting to form an estimate of the results which opticians had been able to achieve from the time that they commenced to apply the resources of scientific research. The formula given above made it clear that there was no possibility of extending the capacity of the microscope by increasing without limit its magnifying power. Means had indeed been found to increase the angular aperture α in a measure as the magnification rose higher and higher, but there was a limit beyond which it was impossible to increase the magnifying power of a lens without reducing the free distance between the object and the front lens to an impracticably small amount, which did not even provide room for a thin cover glass. Continued attempts were made to extend the power of the microscope by increasing its magnifying power. It was soon found that lenses having such extremely short focal lengths as 1/20 inch, 1/50 inch, and even 1/75 inch, in which there was no corresponding increase of the angle of aperture, were in no wise superior in their optical capacity to lenses of lower power, and the trouble expended upon them was clearly wasted. These extremely high powers, of which many examples were produced by the opticians of fifty or forty years ago, have now been entirely discarded, and one rarely meets now objectives having a shorter focus than 1/16 inch.

Opticians then proceeded to concentrate their efforts upon increasing the numerical aperture. Dry lenses had already then been made with apertures of 0.90, and this value has not been exceeded even in these days. Water-immersion and oil-immersion lenses, with their theoretical apertural limits[2] of 1.33 and 1.52, were, however, still far removed from what was practically attainable; in fact, they did not exceed 1.0 in water-immersion and 1.2 in oil-immersion lenses. To carry the aperture further it was necessary to endow the lenses with a greatly improved spherical correction, and much higher demands were made upon the skill of the optician, both in the matter of lens grinding and mounting. By the exercise of an extraordinary degree of skill in the mounting of the front lenses and by clamping them by their extreme ridge, the practical optician has come very near to the theoretical limits, and has been able to realize apertures up to 1.2 in water-immersion lenses and 1.4 in oil-immersion lenses.[3] These were momentous achievements, and it is to lenses of high aperture that bacteriological research owes the greater part of its success. When the limit had been thus reached in both types it was thought to increase the power of the lens by introducing a medium of higher refractive power. Since the transition of light from air ($n = 1$) to water ($n = 1.33$), and that from air to oil ($n = 1.52$) had furnished such striking results, it was expected that the transition to a more highly refracting medium having a refractive index of 1.66 would furnish a means of increasing the aperture still further.

An objective of this kind, in which the immersion medium was monobrom naphthalin, was computed by Prof. Abbe and made by Carl Zeiss in 1889. Its numerical aperture was 1.60. To secure the full advantage of this large aperture it became, however, necessary to satisfy an extensive range of conditions. The condenser must have a similar aperture, both it and object slide required to be joined by a stratum of monobrom naphthalin, and the slide as well as the cover glass had to be made of glass having the same refractive index as the immersion medium, and the object itself had to be mounted in a powerfully refracting medium.

Dr. Van Heurck (Van Heurck, "Le Microscope," 1891, p. 63), who used this objective for a considerable time, and obtained with it many remarkable photographs, including striking photographs of *Amphipleura pellucida*, while praising the great resolving power of the objective, described it as scarcely adapted for regular practical use, both on account of the enormous difficulties which its use entails and its inordinately high price. Of the chief causes which militate against the use of the objective, and indeed render it almost impracticable, Czapski remarks in the *Zeitschrift für wissensch. Mikroskopie*, vol. viii., 1891, p. 149, as follows: Organic preparations require from their very nature to be embedded in media which in the majority of cases have a much lower refractive index than the immersion fluid for which the objective has been computed. This excludes all these preparations from observation with the monobrom naphthalin lens, since one of the principal conditions for the successful use of the lens remains unfulfilled. Even the difficulties which attend the use of the objective and its high price could never have been regarded as a sufficient reason for dispensing with its services if any considerable range of objects existed which could bear being embedded in the media having the requisite optical properties, and in which the capacity of the lens could be turned to full account. As it is, the objective is only known by the photographs taken by Van Heurck, and, as a matter of fact, the lens has long ceased to be manufactured.

There is yet another way of enhancing the working capacity of a lens, as will be seen from the formulæ of Helmholtz. The wave-length of light may be reduced by working with white light having a wave-length of 0.00055 millimeter, or blue light having a wave-length of 0.00043 millimeter, or ultra-violet light having a wave-length of 0.00028 millimeter. Blue light reduces it by 1/4 to 1/5 of its original value, while ultra-violet light reduces it to about one half. A few years ago Dr. A. Koehler investigated successfully what might be accomplished in this direction by the use of light of extremely short wave-lengths (*Zeitschr. f. wiss. Mikr.*, vol. xxi., 1904, p. 129 *et seq.*). An elaborate new apparatus was required to obtain tangible results from the application of very short waves. Even the best glasses that will transmit ultra-violet light did not suffice for the purposes of this investigation, and the only materials which transmitted ultra-violet light of sufficient intensity were fused quartz and fluorspar. The condenser, the object slide, cover glass, objectives, and eyepieces had all to be made from either of these materials, while glycerin served as the immersion fluid. Only a limited number of mounting media were available for use with this apparatus. The lacking intensity of this light rendered it impossible to apply it visionally, and recourse was accordingly had to the photographic method. The difficulties encountered in focusing the object have been overcome by the application of fluorescent light.

The greatest difficulties were encountered in the construction of the objectives. Owing to the limited choice of materials it was impossible to attempt to make the lens achromatic, and indeed this was scarcely a matter of importance, seeing that the light used is almost monochromatic. On the other hand, the use of simple lenses made it impossible to secure spherical correction with respect to more than a small central aperture. This applies at least to a high power dry lens and to an oil-immersion lens of lower power.

There is another circumstance which was found to be a serious drawback, in that the lenses of the objectives had necessarily to be mounted without the usual adjustments by means of which departures in the radii, thickness, distance between the lenses, and irregularities in the homogeneity of the glasses may be allowed for, since it is almost beyond the resources of a workshop to apply any direct test to lenses corrected with respect to the ultra-violet light. It will be readily appreciated that an objective which is made exclusively on the strength of data obtained by calculation without the controlling aid of the optician's art must necessarily be of the nature of chance products. In these circumstances one may either dispense with the highest degree of perfection by accepting an objective as it leaves the optician's hands, or one may from one of a series of several lenses select the one which is best, by direct observation with a fluorescent screen, with a fluorescent eye-piece, or by photographic tests, but such a proceeding would be inordinately costly. Koehler's investigations have the merit of having clearly demonstrated the almost insuperable difficulties with which one has to contend when attempting to apply ultra-violet light. The photographs which have been obtained so far with the aid of ultra-violet light have scarcely furnished any new aspect of the structure of microscopic objects.

* Reproduced from *Nature*.

[1] The apertural angle is the angle subtended by the objective at a point on the axis of the microscope and in the plane of the object.—Editor Scientific American Supplement.

[2] The limiting value of sin α being unity, the limiting value of the numerical aperature $n \sin \alpha$ is n, i. e., 1.33 for water immersion, and 1.52 for oil immersion.—Editor Scientific American Supplement.

[3] It is interesting to compute the resolving power of a microscope with this numerical aperture. Putting $\lambda = 5 \times 10^{-4}$ millimeters we obtain $\epsilon = \frac{5 \times 10^{-4}}{2 \times 1.4} = 1.8 \times 10^{-4}$ millimeters. Prof. Bechhold gives 2.5×10^{-4} millimeters as the limit of resolving power of the microscope. (See Scientific American Supplement, No. 1680, p. 166).—Editor Scientific American Supplement.

APOCHROMATIC AND FLUORITE LENSES.

The labors of Abbe and Schott in the study and production of optical glasses, which were begun in 1881, were to a certain extent completed in 1886. In the technical laboratory established by them under the title of Schott und Genossen, they brought out, in addition to the crown and flint glasses then in use, an extensive series of glasses having markedly improved optical properties and of a different chemical composition. By introducing phosphoric acid and boric acid as components of glass smeltings, in addition to silicic acid, they succeeded in producing new crown and flint glasses, the so-called phosphate and borate glasses, in which the rate of change of the dispersion is remarkably proportional, so that it appeared possible by the combination of these glasses partly to eliminate the secondary spectrum, which hitherto it had been impossible to eliminate to any appreciable extent. In the course of time the Schott works introduced an extensive selection of optical glasses, which greatly simplified the computing optician's work. The list includes glasses of similar refringent properties, but widely different dispersion, and others again having a similar dispersion, but covering a wide range of refractive indices. This was a great advance over the old glasses, in which any increase of dispersion was attended with a rise in the refractive power.

A valuable feature of the new glasses is that the glass works were able to reproduce very closely any of the types specified in their catalogues, and, in addition, every new pot was examined with the spectrometer and its constants recorded. This relieves the computer of the task of having to determine for himself the optical properties of the glasses, and likewise the optician working on the trial-and-error principle was enabled more easily to attain his purpose by a judicious variation of the glasses in accordance with their refractive properties and dispersions. These glasses were used for the first time in apochromatic objectives as originated by Zeiss. This would indeed have been a stupendous achievement if, as the makers of these lenses maintained at first, their success had been solely due to the use of the new phosphate and borate glasses. Unfortunately, as we shall have occasion to show, it was the introduction of fluorite into the composition of the lenses which was responsible for these achievements.

The new objectives, which were completed in 1886, proved a great advertisement for the glass works of Messrs. Schott und Genossen. Of the use of fluorite, however, not a word was uttered, even in a lecture delivered by Abbe on the subject before a scientific gathering and published in the Transactions of the *Jenaische Gesellschaft für Medizin and Naturwissenschaften*, under the title, "Ueber neue Mikroskope," or, as it appeared in a subsequent reprint, "Ueber Verbesserung des Mikroskops mit Hilfe neuer Arten optischer Gläser." Again, not a word was said of fluorite in a paper entitled, "On Improvements of the Microscope with the Aid of New Kinds of Optical Glass," which appeared in the Journal of the Royal Microscopical Society, vi., 1886, p. 20, *et seq.*; neither was it mentioned in a publication prepared for French readers, and entitled, "Nouveaux Objectifs et Oculaires pour Microscopes construits avec les verres spéciaux de la Verrerie scientifique (Schott et Cie.), par Carl Zeiss, Atelier d'Optique à Iena."

Four years passed before the true facts of the case were made known by the firm of Zeiss in an article published in the *Zeitschrift für Instrumentenkunde*, 1890, p. 1, under the heading, "Ueber die Verwendung des Fluorits für optische Zwecke." Long before the publication of this paper other firms, having failed to produce lenses equivalent to the apochromatic lenses with the aid of the new glasses only, had realized that the great advances in achromatic correction embodied in the apochramatic lenses were not due in the first instance to the use of the new glasses, but rather to that of fluorite. Doubtless Abbe had set himself the task of achieving chromatic correction of a higher order by means of the new glasses only, but he failed in accomplishing any very striking results with the aid of these glasses only, and, moreover, the optically most trustworthy glasses could be used in a very restricted sense only, owing to their lack of resistance to atmospheric influences.

We will now briefly discuss the conditions under which glasses combined to form crown and flint glass pairs will furnish a means of securing a more or less complete degree of spherical and chomatic correction.

The older lenses of the achromatic type are composed of two doublet lenses for the lower and moderately high powers, with one or two front lenses of crown glass added for the high powers. The doublet lens consists of a negative flint glass component and a positive crown glass component cemented thereto. The spherical correction is in the main effected at the surface of contact between the components of the doublets. The magnitude of the difference in the refractive indices of the flint and crown glass components governs the curvature of the cemented surfaces, and it should be as high as possible to flatten the surface and to adduce favorable conditions for the correction of the spherical aberration and for securing a high aperture. To eliminate the chromatic aberration the glasses are so chosen that the dispersion of the highly refracting flint may be considerably greater than that of the less refringent crown glass. A good gage of the dispersive properties of a glass is furnished by the formula $\frac{nD - 1}{nF - nC} = \nu$; nF, nD, nC denote the refractive indices with respect to the rays corresponding to the F, D, and C lines of the spectrum; $nF - nC$ stands for the mean dispersion; $\frac{nF - nC}{nD - 1}$ supplies an expression for the dispersive power, while its reciprocal value, usually denoted by the letter ν, is known as the efficiency of the optical medium.

In the list of glasses made by Messrs. Schott and Co. the glasses are arranged in a progressive order of ascending values of the efficiency ν. Glasses in which the value of ν ranges from 75 to 55 are usually classed as crown glasses, while those in which ν has a smaller value go by the name of flint glasses. The combination of a positive crown glass lens with a negative flint glass lens affords a means of correcting the chromatic aberration.

A higher degree of achromatization can be attained, i. e., the secondary spectrum may be eliminated and rays made to meet in a point with respect to more than two colors, if glasses are chosen in which the dispersions proceed by proportional steps. The degree to which this requirement is satisfied may be ascertained by dividing the difference of the refractive indices for two fixed lines of the spectrum, say F and G′, i. e., the so-called partial dispersion, by the difference of the refractive indices for the interval C to F, the so-called mean dispersion. A pair of crown and flint glasses, in which the quotients $\frac{nG' - nF}{nF - nC}$ differ least will be best adapted for the achromatization of an optical combination with respect to a third color.

	nD	ν	q	$\triangle q$
Achromatic Lenses.				
Crown 0.60 ...	1.5179	60.2	0.566	
Flint No. 36-38	1.6202-1.6489	36.2-33.8	0.609-0.615	43-49
Pantachromatic Lenses.				
Phosphate crown 1.....	1.5159	70.0	0.552	
Borate flint ..	1.5521	53.8	0.567	15-31
Borate flint ..	1.6086	44.3	0.583	
Apochromatic Lenses.				
Fluorite	1.4338	95.4	0.561	
Boro-silicate crown	1.5100	64.0	0.559	
Barium-silicate crown	1.5399	59.4	0.566	2-10
Dense barium-silicate crown	1.5726	57.5	0.571	

The table above shows in the first section a pair of glasses such as are used to produce an achromatic lens, and it will be seen to what extent the refractive indices of the components nD and the values of ν should differ to effect the requisite spherical and chromatic corrections. It will be seen that the quotients given in the column headed q, viz. $\frac{\text{partial dispersion}}{\text{mean dispersion}}$, differ by an amount $\triangle q = 43$ to 49 units. With this difference remaining there is still a pronounced secondary spectrum, since the imperfect proportionality in the configuration of the spectra due to the glasses renders it impossible to bring three colors to a point.

The second section typifies the new glasses which were employed to effect a higher degree of correction in achromatic lenses. In the first place, the difference in the refringent properties of the phosphate crowns and borate flints was not sufficient to obtain such flat lens curvatures as are needed to insure a large aperture, at least not with a single pair of glasses. The quotiental difference, $\triangle q$, is in these glasses brought down to 15-31. This alone signifies a very marked advance, and to improve still further upon it one would have to have recourse to denser flint glasses of greater refractive power so as to obtain better conditions for correcting the spherical aberration by flattening the curvature. Even if it had proved possible, by complicating the formula, to evade the presence of pronounced curvatures and to use glasses of a small quotiental difference only, there would still have remained an insurmountable difficulty in that all borate and phosphate glasses are so little permanent as to exclude their use in lenses. An objective containing elements made up of these materials, while produced at a greatly increased cost, could not have failed to become useless in a very short time. Those lens-makers who used these glasses before they had had time to realize their peculiarities had to pay dearly for their subsequent experience.

The third section of the table comprises fluorite and a number of glasses with which it may be associated to form achromatic pairs. The difference in the refractive properties of fluorite and these glasses is not less than in the ordinary glasses, such as enter into the composition of the well-proved older achromatic lenses, and it is sufficiently great to insure the flat curvatures needed for spherical correction. The difference in dispersion is at least equal to that occurring in the achromatic lenses, and hence no obstacles are encountered in bringing two colors to a point. The significant result derived from the use of fluorite is that the difference of the quotients q reduces to 2-10 units, and even almost disappears in some combinations, so that in addition to rays corresponding to the D and F lines of the spectrum a ray of yet another color, corresponding to G′, can be brought to a point. The immense utility of fluorite lies in the fact that its low refractive index is coupled with an extraordinarily small dispersion, by which it differs in a striking degree from the glasses, while yet the quotient is similar to that of the existing crown glasses. The use of fluorite in the place of the usual crown glass component rendered it possible to replace the ordinary flint component with its disproportional dispersion by a crown glass having either a quotient agreeing with that of fluorite or at least differing but slightly from it.

The older silicate crown glasses, which had so far been used in the composition of achromatic lenses, comprise a number of glasses which differ widely from one another in their refractive and dispersional properties, while their quotient is much the same as that of fluorite. By combining fluorite with these crown glasses a means was obtained of producing more perfectly achromatic lenses without the need of a new glass.

It will thus be seen that the new glasses were quite a subordinate element in the composition of apochromatic lenses. There is no doubt that their greater range of variety has made it easier to produce apochromatic lenses, but it is not essentially owing to them that apochromatic lenses have come into existence. In 1891 Leitz made an attempt to produce lenses of a higher degree of correction by the use of glasses only. These were the so-called pantachromatic lenses, the optical qualities of which were intermediate between those of the achromatic and apochromatic lenses. The attempt, however, had soon to be discontinued since those glasses which had proved the best means of endowing the pantachromatic lenses with a higher degree of color correction proved to be liable to deterioration. Within the last ten years several opticians have introduced a new class of objectives, the so-called fluorite lenses, in which the qualities of the former pantachromatic lenses are realized with the aid of fluorite.

These objectives have, so far as the author is aware, the simple composition of the achromatic lenses, and do away with the necessity of introducing a triple lens, which renders them much less costly than the apochromatic lenses. In their degree of color correction they approximate to apochromatic lenses in proportion to the number of fluorite lenses used in the system. Dispensing, however, with the triple lens, they cannot be rendered equivalent to apochromatic lenses, even when the number of fluorite lenses is the same in both systems. On the other hand, it is the presence of the triple lens which adds materially to the cost of the apochromatic lenses.

Reviewing the results achieved within the many years during which the practical optician has been guided and aided by the resources of science, it cannot be said that any epoch-making progress has been made. Yet it cannot be denied that modern men of science and practical opticians have manifested an extraordinary activity in their keen desire to improve the power of the microscope and to extend our knowledge of the instrument.

Comparing the performance of modern lenses with those of thirty years ago, one cannot fail to realize that steady progress has been made. An objective of numerical aperture 1.40 is a remarkable piece of work, and there is scarcely a modern lens that does not bear testimony to the fruitfulness of recent efforts. New types of objectives have likewise been devised for the needs of the photographer, and various new devices for observation by dark-ground illumination, especially Leitz's dark-ground condenser, have developed this method of observation in a surprising manner. The indefatigable activity of opticians as well as physicists has elucidated the nature of the problems relating to the limits within which it is possible to improve the microscope, and has given us a better insight into the *modus operandi* of the instrument. It may suffice to remind the reader of Abbe's theory of optical instruments.

Special Grooved Revolving Shoes Permit the Cars to Pass the Steel Supporting Towers Without Jolting.

Scaling Mountain Peaks by Elevator

Aerial Ropeways for the Tourist

By the English Correspondent of the SCIENTIFIC AMERICAN

The rack railway for tourist traffic has in many instances proved an unprofitable investment. The solution of the problem of "mountain climbing made easy" seems to have been found in the use of the cable suspension railway, which is working very successfully in the Swiss Alps and in Tyrol.

Looking Down the Line Into the Bozen Valley. The Track Here is 90 Feet Above the Ground.

DURING the past few years the question of conquering new mountain peaks in the European Alps has undergone a startling change. The completion of the rack-rail up the steep slopes of the Rigi in 1871 ushered in the era of the mountain cogwheel railway, which proved highly successful, being heavily patronized by the American and other visitors to Switzerland. The cogwheel system, however, has its limitations. It is restricted to mountains comparatively easy of ascent, so that the cost of construction may not be so high as to render the available traffic sufficiently remunerative to permit a fair return in dividends upon the capital expended. The successful completion of the Rigi and Pilatus lines in the face of stupendous difficulties precipitated a Swiss mountain railway fever, and the result was that innumerable lines were laid down where there were no possibilities of adequate revenue accruing to defray the debenture interest. The result was that many lines went into the receivers' hands.

This dramatic ending brought about a more careful building policy which was carried to the opposite extreme, with the result that during the past decade very few new cogwheel railways have been laid down. The inclined railway working upon the counter-balancing system had a short vogue, but the same objections were encountered. The track had to be of solid construction to fulfill the rigid official requirements for safety, and the preparation of the road bed entailed heavy expenditure.

Then Herr Feldmann, who had supervised the construction of the Barmen-Elberfeld suspended railway, conceived the idea of adapting the aerial system to mountain railroading. He devised a system capable of fulfilling in every particular the searching safety requirements, and was also able to induce a Bernese firm of manufacturers to adopt his new system. After prolonged negotiations the Government gave permission for this electric lift system to be employed upon the Wetterhorn, where a difference of 1,380 feet in altitude is overcome in a single span, the passengers being whirled across the Rhône glacier.

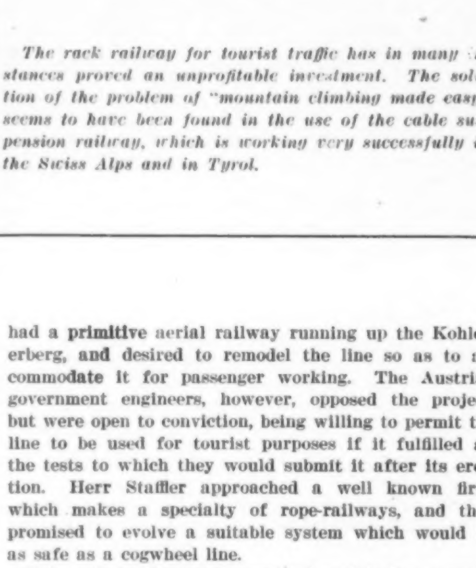
Although this aerial system proved completely successful and absolutely safe under all conditions of working, the suspension idea did not provoke very marked enthusiasm. No doubt the novelty of the idea was somewhat responsible for this state of affairs, as the timidity of the travelers had to be overcome. On the other hand the system was so much cheaper to install, while the maintenance and running costs were so much lower that it held out many attractions. At the same time the Wetterhorn undertaking demonstrated the applicability of the idea to mountains, the flanks of which were so precipitous as to prevent the building of a cogwheel or incline line.

During the past few years European engineers have been devoting their attention to the perfection of the suspension railway system. It had proved highly remunerative in the handling of freight, and so long as absolute safety under all conditions was maintained, there was no reason why it should not be equally applicable to the conveyance of passengers.

Herr Joseph Staffler of Bozen, in the Austrian Tyrol, had a primitive aerial railway running up the Kohlererberg, and desired to remodel the line so as to accommodate it for passenger working. The Austrian government engineers, however, opposed the project, but were open to conviction, being willing to permit the line to be used for tourist purposes if it fulfilled all the tests to which they would submit it after its erection. Herr Staffler approached a well known firm, which makes a specialty of rope-railways, and they promised to evolve a suitable system which would be as safe as a cogwheel line.

This railway has been completed, and to-day it ranks as one of the most interesting systems in the Tyrol. Unlike the Wetterhorn suspension railway, the 5,250 feet difference in altitude is not overcome in a single span. This was impracticable, the line had to follow the contour of the mountain, involving the introduction of intermediate supports.

The line is provided with two tracks so as to permit



The Driving Gear, Showing Motor.

of operation upon the counterbalancing system. Each track comprises two steel wire cables placed in a horizontal plane and spaced about 18 inches apart, and suspended on the average about 20 feet above the ground. The cables are anchored firmly in the mountain side at the upper station, while at the lower station they are attached to counterweights whereby the ropes remain under an even tension. The factor of safety is 5.

The disposition of the carrying cables for each track insures perfect safety for the passengers, and at the same time reduces the wear and tear on the curves. The cars are attached to a double hauling rope of cast steel wire, wound round large sheaves in the upper station, these pulleys being driven direct by electric motors. By reversing the motion of these pulleys the traveling direction of the cars is reversed. The ropes also pass over balancing pulleys whereby the tension of the two ropes is distributed equally. Under the most unfavorable conditions the hauling cables have a factor of safety of 8. On the opposite side of the cars, i. e., facing the lower station, are ballast ropes which serve to balance the weight of the hoisting cable, and in the lower station these are attached to automatic tension devices, whereby the tension on the ballast ropes is kept even.

The towers supporting the track are disposed at intervals according to the contour of the ground. They are lattice steel structures, mounted on heavy foundations carried down to the solid rock. The cables are supported on projecting brackets fitted with cast iron grooved shoes which revolve at the moment the car is passing. By this arrangement the car is able to pass over the support without the slightest jerk or vibration, while at the same time the weight of the vehicle is distributed equally between the two-track cables. The height of the towers varies according to the slope of the mountain side, but they range from 20 to 100 feet. Of course, if desired, as in exceptionally rugged districts, the height of the towers may be increased to meet the prevailing conditions.

The installation is driven electrically, the power being drawn from a generating station in the vicinity, and transmitted to the upper station by overhead conductors. If no such source of supply is available a Diesel or other motor may be used for generating the electricity upon the spot. As the power for aerial railways, although not great, fluctuates between a maximum and a minimum, in the same manner as with electric street cars traveling over undulating country, it is necessary to make provision for these variations. In this case an accumulator battery is employed which takes up all the excess of electric energy.

The driving mechanism comprises two or three pulleys around which the hoisting cable is passed several times. The main pulleys is driven from an electric motor by an inner wheel of the desired gear ratio to give the requisite speed. The driving mechanism is fitted with three brakes, the principal of which is automatic in its action, or hand-operated, and is connected directly with the driving pulleys, thereby dispensing with connecting links.

On the Kohlererberg Railway the car has a seating capacity for 16 passengers, but larger or smaller cars may be used according to the exigencies of the traffic. The car is suspended from the traveling truck in such a way that it maintains a vertical position irrespective of the gradient of the track. The car, in order to reduce weight, is made of aluminium and wood, and is of the observation type with large plate-glass windows. The roof is flat, so as to facilitate movement thereon when it is necessary to examine the traveling truck mechanism and the overhead track.

The framing whereby the car is suspended from the truck is made of nickel steel, of ample strength and

weight, and of an inverted V shape, being connected to the traveling truck by means of two strong pins on which it swings, so as to maintain its equilibrium. This suspending frame is fitted with a platform, gained from the driving deck of the vehicle by means of an iron ladder, to provide access to all parts of the machinery. The traveling truck is fitted with eight wheels, four running on each track-cable, and the weight of the suspended vehicle is distributed equally over these eight wheels. The truck is fitted with automatic catches, independent of each other, furnished with four brakes, for gripping the carrying cables.

In such a railway as this the requisite machinery can be accommodated within a small space, so that the station covers but little ground. If such a railway is intended to traverse a considerable distance, the line is divided into sections of about 3,300 yards each, this factor being governed by the difference in level to be overcome, and the driving energy required, so that shorter lengths may be used if the character of the country demands it. By this arrangement each section is converted into a tangent, the connections being made at an angle station so as to secure continuity of track.

In the system here described elaborate safety precautions are incorporated. Should a carrying cable break from any unforeseen circumstance, the remaining cable is quite able to carry the car, thus emphasizing the value of the double cable-track method. Should a cable fail while the car is between the two stations, a patent device in the upper station automatically brings the car to a standstill, and then permits the journey to be resumed steadily on the remaining cable. The design of the traveling truck, and the car suspension frame, is such that a derailment, or the fall of the car from the track, is impossible. The upper part of the suspender spans both cables in a bent manner, so that if one of the pivot pins from which it is slung were to fail the frame would still span the cables. The car itself is so constructed that should a cable break, it cannot possibly foul and become entangled with the vehicle and its mechanism.

The car machinery is fitted with two catches, which work independently, and these automatically become applied to, and clutch the cable tightly when the car attains too high a speed, or, in the event of the two hauling cables breaking. Each of these catches operates two brakes on the cables, and one catch alone is adequate to clip the car irremovably to the track. In the official tests the ascending loaded car was traveling full speed when the hoisting cables were detached purposely. The brakes at once came into action, and the car slipped back less than six inches before it was gripped to the cable by the automatic catches and brakes.

The driver is provided with a wire and telephonic apparatus to enable him to keep in constant communication with the driving station during his journey. Consequently should anything go amiss he can have the vehicle stopped immediately. At the same time he is quite independent of the driving station and the automatic grips, if he desires to stop the vehicle en route. On the platform of the car is an emergency handle, the movement of which by the attendant stops the car instantly.

Over-running into a station is also provided against. It may happen that the mechanic in charge of the driving installation through oversight or carelessness may omit to cut out the drive sufficiently quickly. The car, however, can only traverse a certain distance, as the main brake is brought into action by a check device in the upper station, thereby stopping the car. When it becomes necessary for the car to back out on another journey there is no possibility of the driving gear being set in motion in the wrong direction, as the gear is arranged to prevent such movement; the car must travel in the reverse direction.

Provision of an adequate character is provided also against failure of the current. In such an event the main brake on the driving gear acts electro-magnetically, thereby stopping the mechanism. To meet such an emergency the accumulator is brought into action when the brake is released, and several journeys can be completed on this supply until the service current from the central station is resumed.

In the driving station the engineer is provided with indicators which show the positions of the cars upon the cableway constantly during the trip, so that he is familiar throughout with their positions and speed. Directly the velocity exceeds the limit prescribed by the authorities, the speed regulator actuates the main brake of the driving mechanism, thereby checking the speed of the vehicles until they are restored to the normal. Similarly as the cars approach their respective stations the speed is reduced automatically, so that they come to a stop without the slightest jolt.

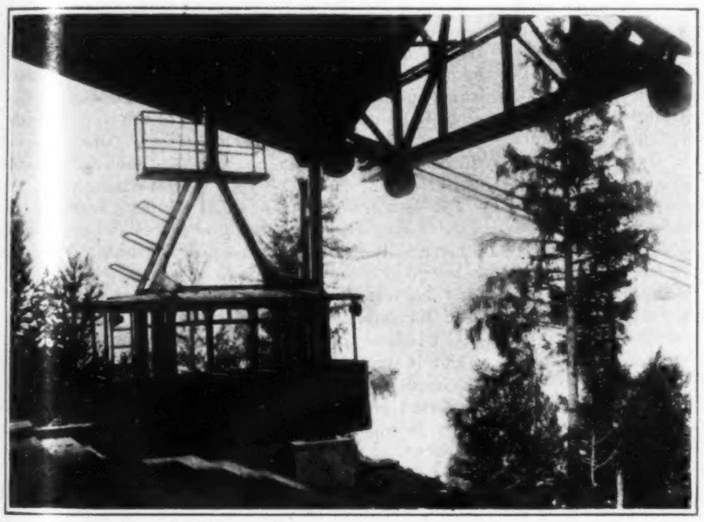
The signalling system between the two stations is elaborate, being both visual and audible, and these signals have to be received and acknowledged before the cars can be started. During rough weather the railway must not be employed for passenger service, the authorities having set a limiting wind velocity which is considered to be dangerous to exceed. While there is not the slightest likelihood of any ill results arising from traveling during heavy storms, the regulations of the officials must be obeyed. On the roof of the upper, or driving station, an anemometer is placed, and there is a device whereby, when the anemometer registers the limited wind velocity, a bell is set ringing, warning the attendant to suspend railway operations.

It is quite possible, however, despite the precautions adopted, that the cars may become stranded on the cables mid-way between the stations. A small handworked emergency car is retained for such contingencies, and this can be sent along the cable to take off the passengers. Even, if this should fail there is no danger of the passengers being stalled indefinitely in mid-air. As a last extremity the ground beneath may be reached by a life-saving apparatus. This comprises a collapsible bag, with a rigid base, which is let down through the floor of the car, and in which the passenger is able to stand upright. Hurried descent is impossible as the lowering gear is controlled by a brake, enabling the ground to be reached without any perceptible jar.

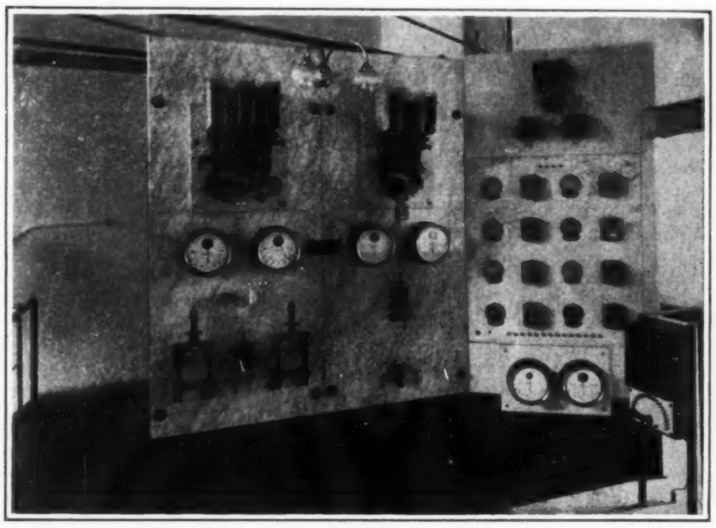
Upon its completion the Austrian Government engineers subjected the system to prolonged and searching tests to be assured that passengers traveling thereby were safeguarded against every conceivable disaster, short of the collapse of the double track—a contingency so remote as to be ignored. Some time was taken in convincing them, probably owing to the novelty of the new transportation idea, but in the end they gave official consent. The lower station is at Eisack and the ascent of 5,250 feet is made at a speed of 10 feet per second, the journey occupying about 13 minutes. The view obtained during the trip is magnificent, embracing, as it does, panoramas of the Ritter, the whole of the Bozen Valley, the Ortler Range, and the heights of the Schlern. The comfort in traveling is particularly noticeable, the car gliding along without the slightest vibration or oscillation.

The success of this initial enterprise has resulted in greater attention being devoted to the possibilities of the mountain aerial railway. The system employed is generally acknowledged to be excellently conceived, designed, and applicable to any type of mountain. Rapidity and cheapness of construction are outstanding features, the Kohlererberg Railway having been completed in the short space of twelve months. At the same time it enables the railways to follow almost an air line between points, instead of involving curves to maintain a suitable grade and to avoid obstacles. The earthworks are eliminated, being confined to the foundations for the towers.

The maintenance expenses are also low in comparison. The track suffers no damage from snow, and the cables cannot become loaded, as they are kept clear by the traveling truck. The power required for operation is very slight, as the descending car counterbalances the ascending vehicle. Both loads being of equal weight as a rule, current is consumed only in overcoming friction, and the loss of power in the driving gear. Under these circumstances, and all things considered, it is not surprising that further schemes for ascending precipitous mountains in the Alps by aerial means are being projected. The lower initial, running, and maintenance costs will enable new peaks to be brought before the tourist which it would be impossible for them to reach otherwise, owing to insufficiency of traffic rendering them unremunerative, while the same conditions will enable a reduction in the expense of ascending to such heights to be achieved, and this will impress the average tourist effectively, as mountain railway traveling is proverbially costly under present conditions. The system seems, indeed, the ideal one for its purpose.



The Upper Station with Car at Rest, Showing Access by Steps.



The Switchboard With Telephone and Lights for Acoustic and Visual Signalling.

The Literature of Microscopical Optics

To what extent the study of microscopic optics has occupied the minds of research workers is eloquently borne out by the vast literature which during this period deals with the microscope. Of journals devoted to the study of the microscope we may mention the *Zeitschrift für wissenschaftliche Mikroskopie*, the *Journal* of the Royal Microscopical Society, and the *Journal* of the Quekett Microscopical Club. The microscope forms also the subject of extensive works, among which one may mention those of Abbe, Dippel, Lummer, and Reiche, van Heurck, Wright, Spitta, and Carpenter. A number of meritorious works have been published which, while dealing with optical matters in general, go far to further the development of microscopical optics. Of the authors who have written on geometrical optics and optical instruments we may mention Ferraris, Herman, Maxwell, Lord Rayleigh, Heath, Gleichen, Drude, Czapski, von Rohr, Whittaker, Gullstrand, Leathem, Schwarzschild, Maclaurin.

It has often been said that the microscope has reached the limits of its resources. Certain it is that it has needed the application of the utmost skill and the most strenuous efforts to enhance the powers of the microscope during recent years. There is, however, every prospect that the ever-extending use of the instrument, the increasing demands made upon it, the intense scientific attention bestowed upon its development, and the fine training of the modern optician will not fail to maintain progress.—*Nature.*

Preliminary Report to the Inventors' Guild—II

The Guild's Relation to Patent Practise

By F. L. O. Wadsworth

Continued from Scientific American Supplement No. 1940, Page 147, March 8, 1913

The question is what can best be done to remedy the present evils. Several things can be done. In the first place the questions of patentability and prior public use whenever they may arise—at the declaration of the interference or during the taking of the testimony by either party—can be first settled by the decision of a duly constituted board, the decision of which shall be binding on both parties to the interference or any other parties in privity. In the second place it may be provided that neither party shall be allowed to take more than a stipulated amount of direct testimony—say one hundred printed pages—and if the cross-examination by opposing counsel exceeds an equal number of pages, his client shall be compelled to pay all expenses of the other party in the taking of such excess testimony. In the third place the number of appeals in interference suits can be reduced from three to one. If the proceedings are conducted in the Patent Office only one hearing and one tribunal is necessary. This should be made up of a special board constituted as described below. (*infra.*) Appeals from decisions of that board should be taken direct to the Court of Appeals of the District of Columbia.

Another suggestion that has been made is that interference contests, like infringement suits, should be conducted in the Federal courts, the hearings being held behind closed doors to prevent the premature disclosure of unpatented inventions. This suggestion has many points in its favor. It is even now possible to bring the issues of an interference before the Circuit Courts on direct or by cross bill, but this can only be done after those issues have been decided in the usual course of an interference contest in the U. S. Patent Office. An adjudication of the matters in dispute in the Federal courts in the first place would go far toward establishing the patent rights of the successful contestant in subsequent litigation on the issued patent.

Appeals from the rulings of the Primary Examiners on matters of patentability, etc., are, under the present law a vexatious, expensive, and troublesome procedure, which may involve the argument of the case before *three* successive tribunals: 1st, The Board of Examiners in Chief, consisting as at present constituted of only three members; 2nd, The Commissioner, or First Assistant or Assistant Commissioner, and 3rd, The Court of Appeals of the District of Columbia. This is all unnecessary and unduly cumbersome and expensive. There is no necessity for more than one appeal in the Patent Office. Let this be from the Chief Examiner direct to a special appellate tribunal made up say of a Presiding Officer and four, instead of three, Examiners-in-Chief, any two of the examiners and a presiding officer being empowered to hear and decide a case. This would enable this appellate tribunal to sit in two divisions, if necessary, to expedite the conduct of business in the office, and avoid any delay in hearing cases. In particularly important cases provision might be made for ordering a full bench of the five judges. From the decision of this tribunal or either division thereof, appeal would lie at once to the Court of Appeals of the District of Columbia.

This same tribunal would also constitute the special board which would hear and decide interference suits, if the conduct of such suits should be left in the hands of the Patent Office. The establishment of a special tribunal and board has been repeatedly urged upon Congress by Commissioner Moore of the Patent Office and a bill providing in part for the reforms above outlined was passed by the Senate during the 60th Congress, but was not acted upon by the House of Representatives. Bills were introduced into the Senate (S. 5,636) and the House of Representatives (H. R. 18,805) which provide for the elimination of one appeal in *ex parte* cases, and interference cases. But this does not go far enough. Either two appeals should be eliminated in interference cases, or those cases taken out of the Patent Office entirely and transferred to the Federal Courts.

(4) The transfer of the U. S. Patent Office from the Interior Department to the Department of Commerce and Labor might greatly facilitate the initiation and consummation of the improvements and reforms which are contemplated. It is as a rule easier to bring about a change in an established order of procedure under a new management or administration than it is under an old one. A governmental department is particularly averse to making any change in its particular routine method of conducting affairs, especially when the suggestion for such changes comes from outside. Such suggestions are generally regarded as a reflection on and a criticism of the administration of the department under which the work has been carried on, and are resented—apparently on the assumption that "the king can't do no wrong." In connection with, or independently of such transfer—which can be made by the President without the intervention of Congress—it is suggested that provision be made for the appointment of an Expert Commission or Board of Visitors to be composed of representatives appointed from the membership of the Inventors' Guild, the Patent Division of the American Bar Association and the four National Societies of Engineers (Mechanical, Civil, Mining and Electrical). This Commission or Board would co-operate with the Commissioner in instituting and effecting reforms in the Patent Office, in influencing legislation necessary for the accomplishment of those reforms; in bringing the work of the office in closer and more effective working relations with the industrial world ; and in establishing more satisfactory international agreements for the protection of foreign patent rights.

(5) The Circuit Court of Appeals act (1891) makes the decisions of those courts final in suits for infringement, and closes the general right of appeal in such causes to the Supreme Court of the U. S. Only in very rare cases can such cases be taken up to the Supreme Court on a writ of certiorari, and it is optional with this court as to whether or not such writ shall be granted. There are nine Circuit Courts of Appeal in the U. S. and there is at present considerable confusion of opinion among the judges of these various circuits as to various fundamental questions of fact which are constantly arising in patent causes, and a considerable variation of judicial attitude as to the rights of owners of patents. It has frequently happened that one and the same patent has been sustained in one circuit, and declared invalid in another; and the state of confusion and uncertainty that has resulted from such conflicting decisions is completely at variance with the true intent and spirit of our patent statues, and is repugnant to one's sense of right and justice. The inventor, the manufacturer and the general public are alike sufferers under such a state of chaos.

The restoration of the right of appeal to the Supreme Court in all patent causes would restore harmony, and would secure adjudications of patent rights that would hold good for the entire country. Such a reform would not, however, be practicable for the reason that it would be impossible for the Supreme Court to dispose of the enormous amount of work that would thus be thrown upon it. But aside from this the plan of carrying up all patent causes from our present courts of appeal to the U. S. Supreme Court is objectionable in that such a procedure involves too much delay and expense. It seems entirely unnecessary to submit a case to three tribunals in succession. One solution of the difficulty that has been suggested is that a new court of Patent Appeals be established, as a court of last resort in patent causes—all patent suits to be appealed at once from the Circuit Court, in which they are first heard as now, to the Court of Patent Appeals. It is proposed that the latter should be composed of judges especially selected for their qualifications for passing upon questions particularly involved in patent causes. The number of judges in this court should be large enough to enable it to sit in two or more divisions, if necessary, and thus hear and decide all cases brought before it with expedition and dispatch. It might be advisable to have all hearings in Washington or it might be advisable to hold terms in different parts of the country. The general plan only is here outlined; details and various arguments both pro and con will be presented later.

Another plan which has been suggested involves not only the establishment of a Court of Patent Appeals but the establishment of an entire new Patent Court consisting: First, of nine special judges, one sitting in each of the nine circuits, whose only duties should be to hear, try and determine patent causes, and second, of a Central Court of Patent Appeals comprising five or more judges sitting in Washington as a court of final appeal. All of the judges, both of the Circuit and of the Appeals Courts, would be selected with special reference to their training and experience in patent law and the technical matters involved in patent causes. Such a Patent Court would be eminently qualified to pass upon the questions presented to its consideration, but the establishment of such a court presents difficulties and would probably meet with considerably more opposition than would the establishment of a Court of Patent Appeals alone.[1]

(6) A very great part of the present delay and expense attendant upon the preparation of patent cases for final hearing is due to the absence of any restriction upon counsel as to the employment and examination of patent experts. The license which has been allowed in the past, in some cases at least, has been most egregiously abused, and enormous records have been piled up without any essential benefit to either side, simply because the partisan experts have quarreled over a great mass of entirely irrelevant and immaterial details, and have been afraid to agree on even the most obvious and clearly indisputable proposition. My feeling is that this condition of mind on the part of the great majority of experts can only be cured by a radical change in the present method of calling such witnesses. My suggestion is that they be called by the court, one, or at the most two experts, being appointed at a preliminary hearing of the case, at which time the counsel for the complainant shall outline the general issues of the case and specify the claims of the patent on which suit is brought. These appointments would be made from a joint list submitted by the counsel of the opposing parties and the direct examination of such experts would be conducted by the Master, the examination being strictly limited to the points on which the court desires enlightenment. Both parties would have the right to cross-examine such experts and at the time of final hearing such experts would be required to be present in court to answer any further interrogatories which the court itself might desire to propound. The cost of the direct-examination and of the court attendance of the expert or experts, would, in this plan, be divided equally between the parties and each party would separately pay the cost of its own cross-examination.

I believe that the plan would eliminate much of the present unnecessary discussion of trivial and immaterial differences between the processes or apparatus or articles in controversy and would leave an expert free to express fully and frankly his views as to the material issues. Indeed, the expert, when appointed in this manner, would have no reason to evade the discussion of any question that might be presented for his consideration or to obscure the issues by unnecessarily prolix dissertations upon controverted points. He would on the other hand have every incentive to a full, frank and clear exposition of his views, as any other course would justly subject him to the severe censure of the court and would be likely to end his future career as an expert. The result would be a great abridgment of our present compilations of verbal fencing matches between experts and opposing counsel, and a wonderful clearing up of the ground which has to be gone over at final hearing on the merits of the case. I cannot see that this plan would work hardship on either party as any attempt to befog and confuse the real issues of the case by expert (?) testimony usually reacts, and should always react, against the parties employing such tactics.

About the only hardship (?) that would result would be in depriving some of our present so-called patent experts of their means of livelihood. This, however, can hardly be viewed as a calamity.

(To be continued.)

[1] A most excellent paper dealing with the questions discussed in this section was published by Mr. William Macomber in the *North American Review* for June, 1910. See also report of the Patent Committee of the American Bar Association, Chattanooga meeting, August, 1910.

Dimensions and Muscular Power of Animals

In a recent number of *Science* A. S. Hawkesworth remarks:

"It is a well known fact of observation that the smaller creatures are ever the more vigorous. A flea is proportionately vastly more powerful than a cat; and the cat than an elephant. While in paleontology giantism is, I think, recognized as a stigma of degeneracy, preceding racial extinction.

"Now, may not these observations be embodied in the following single mathematical form:

"The weight of any two similar animals is plainly proportionate to the *cube* of their heights. While their muscular power may surely be taken as proportionate to the area of the similar cross sections of corresponding muscles; and thus proportionate to the *square* of their heights. So that, of two cats say, if B be n times higher than A, then it is n^3 times heavier; but has only n^2 times more muscular strength. And is thus really $1/n$ proportionally weaker. For, plainly, during any corresponding exertion, it must move n^3 more weights, with but n^2 more strength."

Methods of Fire Prevention

Excellent Work Done by the British Authorities

[An engineering correspondent of the London Times makes a very interesting communication on the work of the British Fire Prevention Committee, which we reproduce here in slightly abridged form.—Editor.]

Never so much as at the present time have those technically concerned in fire prevention accorded that subject so close an interest.

The term "fire prevention" had its origin in England, the modern fire-preventive propaganda first emanated from London, and the metropolis was the first city in the world to have a permanent testing station for fire-resisting materials, fire appliances, and kindred objects; and all other countries have practically had to come to London to learn the principles and precepts adopted, and to follow them as best they could and local circumstances permitted. The two countries so great in scientific research in other departments of life, Germany and America, have not yet reached anywhere near British standards and British practice in fire-preventive investigation. In New York, for instance, most useful fire tests are undertaken with proprietary systems of construction at the Columbia University Testing Station, but they are only occasional and promiscuous. No data are published except on rare occasions, and failures, the most instructive features of such tests, are kept secret. In Chicago an excellent equipment for fire testing has been installed by the underwriters, but the tests are conducted solely in the interests of the insurance companies for their own private information; no scientific reports on the investigations are published, and the whole idea underlying the institution is that of an insurance mutual protection society. In other words, America does little or no systematic and continuous research work in the interests of the public at large.

In Germany, Berlin alone accords some slight attention to fire research, and only in a very haphazard manner, as a kind of subsidiary or minor subject at its Gross Lichterfelde Royal Testing Laboratories. The plant devoted to fire tests at that institution is of a most elementary character, while the testing arrangements are unpractical to a degree and form an extraordinary contrast to the usual thoroughness with which investigations are conducted in Germany. Occasional fire tests are also to be heard of in France, Belgium, Denmark, Austria, and Russia, but they are not systematic.

British Fire Prevention Committee.

The position of this country in this particular branch of research work is due almost entirely to the work of the British Fire Prevention Committee, which formed the first permanent fire-testing station in Europe in 1898, and has since conducted a constantly increasing number of fire tests and investigations, which have embraced a wide field, from such simple subjects as ordinary wooden doors, say of a dozen different types of timber, to the most complex forms of reinforced concrete flooring. Objects in every-day use, such as flannelette garments, celluloid combs, and "fire-proof" safes, have also been brought under test, and the committee's reports include information regarding many of the fire-extinguishing appliances, from the ordinary bucket and hand pump to the application of foam on petrol fires.

After this preliminary indication of the scope and character of the fire research work conducted in London, it may be of interest to turn to the results of some of the more recent investigations of the committee, which clearly indicate the trend of modern fire protective work.

Fire-Resisting Glazing.

Probably the most interesting series of tests of the past two years have been those conducted with fire-resisting glazing. Some years ago "wired-glazing" and "electro-glazing" had already been put before the committee, and had been carefully tested and investigated, with the result that glazing of certain limited sizes (2 feet by 2 feet), both "wired" and "electro," was classified as affording "temporary protection." The glazing within these limits has since been largely used, both in building construction generally (subject to local regulations) and in buildings subject to insurance rules. The limit of 2 feet by 2 feet has, however, been considered a small one, and further new comers have arrived in the glazing industry. Hence a number of tests have been carried out with different forms of electro-glazing, of larger size and under higher temperatures and for longer periods than in the earlier investigations, with the result that to-day it can be said to be possible to make electro-glazing of ¼-inch plate glass measuring 3 feet by 2 feet, that will stand fire for so long a period as 1½ hour under a temperature reaching 1,500 deg. Fahr., while so large a size as 4 feet by 2 feet can be safely relied on to withstand tests of an hour's duration under the same conditions.

When it is remembered that the best hardwood doors 2 inches thick will scarcely stand an hour's test up to 1,500 deg. Fahr. under the British Fire Prevention Committee's standard conditions, it is a remarkable achievement for the electro-glazing trade to have developed their work to such an extent, for there are even records of six window panels, 2 feet by 2 feet, standing a temperature of 1,750 deg. Fahr. for an hour and a half, and of a 4 foot by 2 foot casement standing 1,600 deg. Fahr. for an hour. The modern electro-glazing practically equals in resistance ordinary solid partitions of 2½ inches and surpasses ordinary solid wood doors from the fire point of view.

British wired-glazing has not yet come into the field of higher competition. The maximum result achieved in 1905 by a wired-glazing of British manufacture vertically placed was the resistance of a temperature up to 1,500 deg. Fahr. for three quarters of an hour. This test has, of course, now been much outdistanced by electro-glazing, and although the latter may be more expensive, it has also the advantage of being more usable and decorative, being quite transparent and of higher finish. Thus British wired-glazing is with some few exceptions (where polished) relegated for the time being to what may be termed rough work where appearance does not matter, and even there only for the limited fire resistance of 45 minutes. The warehouse or factory owner who wishes to separate off certain rooms effectively, or to protect himself against external hazard of a higher degree than heretofore, will no doubt spend the additional money on electro-glazing. In the Colonies building owners could, of course, obtain some of the American wired-glazing which was tested in London in 1906 with good results up to 2 feet by 2 feet, but this material does not appear to be imported into England.

Fire-Resisting Doors.

Another question that has been under close review at the committee's testing station is that of fire-resisting doors. The technical professions concerned, as also the authorities controlling these matters, are by no means satisfied that perfection has yet been reached in door construction, and while in the earlier years of the committee's investigations the doors under review other than hardwood doors comprised either the various forms of tin-clad wooden doors (with or without asbestos linings of various thicknesses and of various makes) or the different types of iron doors (more commonly described as party-wall doors) of different materials, designs, forms, and thicknesses, the trend of investigation has of late gone in the direction of composite doors and of roller shutter doors.

Of the composite doors, various forms have been put forward, from the pure reinforced concrete door held in a metal frame to highly finished thin steel plate doors with air spaces or asbestos, slag wool, and similar non-conductive fillings. Roller shutters are doubtless well adapted for large openings, inasmuch as the door protection, instead of occupying wall space when open, can be rolled up to a position above the door opening, and so is out of the way. Openings 7 feet wide and 8 feet high can be efficiently protected in this manner, but it is a mistake to suppose that a roller shutter door, because it has withstood an official test to an opening of, say, 7 feet by 8 feet, can withstand fire on larger openings. The secret of its resistance lies in the fact that a properly made roller shutter slat allows sufficiently for contraction and expansion. Up to the present two forms of roller shutters have been under investigation and satisfactory results have been recorded.

A word of warning should, however, be given against the assumption that because two makes of roller shutters have passed an official fire test reliance can be placed on others the quality of which has not been proved. Roller shutters can be judged only by actual fire test under standard conditions, whereby the results can be compared with other forms of door protection also tested under standard conditions. The variety of material and patterns suggested for roller shutter doors is so great that it should be plainly stated that some shutters are untrustworthy, and may even be dangerous because they give a sense of false security. Civil engineers and architects should, therefore, be wary in their specifications, and should not allow the mere fact of certain forms of roller shutter having proved satisfactory to induce them to specify others, no matter how similar they may appear in photographs. The roller shutter is dependent on the fire resistance of its weakest link, and largely on matters of detail. An unsuitable slat joint, an unsuitable guide, or an unsuitable roller may each entirely discount the practical value of the principles of roller shutter door construction, which, while most excellent in themselves from a fire point of view, unfortunately lend themselves to bad execution.

In composite doors, again, the danger lies in matters of detail not being properly observed and in the rapid decrease of fire resistance in proportion to the increase of the opening to be protected. Doors of the highest possible efficiency and excellence, which as single doors thoroughly protect an opening of, say, 3 feet by 7 feet high, are often absolutely useless on say a width of 7 feet with the same height. Here again architects and engineers should not specify doors for large openings which may have passed the official standard tests only to a smaller size, and should be cautious about deviations from the specifications to which the original tested doors are made. Finish, it should be added, also counts for much in these composite doors, for, as indicated above, it is the weakest link and slip-shod detail that count so much at a fire.

The British Fire Prevention Committee has, during the last few months, again been testing six composite doors from the United States and from Belgium. Simultaneously a summarized report in tabular form has been issued on no fewer than 58 doors tested by the committee during the last ten years, and thus a useful *précis* of the whole subject of door protection covering no fewer than 64 types has become available. Yet the subject is by no means exhausted, and numerous unproved doors are still put on the market and purchased by a too confiding public.

Reinforced Concrete Floors.

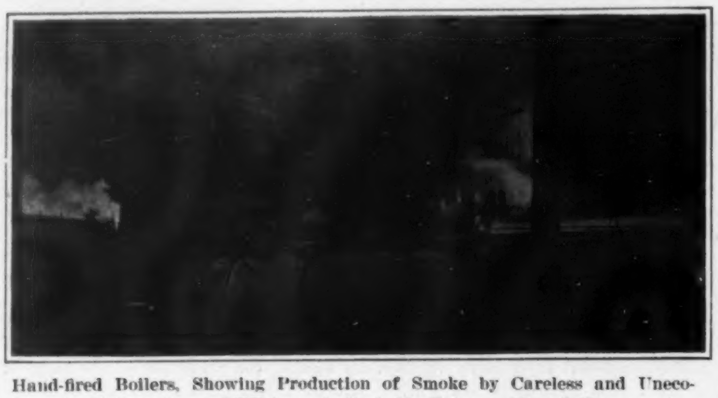
In another direction the investigations of the committee have lately been of an instructive character, and, completing one series of floor tests—some 28 in number, including tests with some well-known older systems of construction—and issuing a summarized report on the results in tabular form, it has started fresh investigations with newer systems of design. Thus while the reinforced concrete floor, including systems of bar reinforcement, has been dealt with fairly fully, some tests have now been initiated with floors in which metal wire mesh is used as reinforcing material. There must be a considerable difference in the fire resistance of reinforced concrete slabs according as they are reinforced with bars or with the reinforcing mesh. There must be a difference of conductivity in the metal, and perhaps less protection is required with the thinner metal reinforcement than with the metal rod. Investigation alone, conducted on standard lines, can elicit the necessary facts, and it is a mistake to suppose that because one form of reinforced concrete floor has passed a satisfactory fire test every other form of reinforced concrete floor can do the same. Existing floors can certainly be improved upon from the fire point of view, and economies as to thickness and protective covering are possible.

That this problem of the fire resistance of reinforced concrete floors is to become one of international importance may be gaged from the fact that the International Association for Testing Materials—a body which has so far not concerned itself with fire problems—went out of its way at its recent congress in New York to form a special sub-committee to inquire into the question of fire resistance of concrete, and further decided to use the British Fire Prevention Committee's standards as a basis to work upon. Thus the tests of the near future in London should be of international importance, but unfortunately the means of the committee do not permit it to go into the matter so extensively as the subject merits.

Roofs and Partitions.

Cement or asbestos cement roofing is one of the modern materials that may have a great future. It is curious, however, that such roofings have never been offered for serious investigation from the fire point of view, and it is only during the last few weeks that a Canadian firm of high repute put forward for fire test a corrugated asbestos cement roofing material which is intended to supersede galvanized iron corrugated sheeting, not only on account of fire resistance, but also as a non-conductor of heat, an all-important property in tropical climates. Two materials belonging to the felt roofing class have been under test, but makers of other forms of composite imitation slate and roofing slabs have not offered their materials for test.

The Effect of Acid Rainwater on a Galvanized Water Pipe of Cheap Bessemer Steel in Service About Five Years.



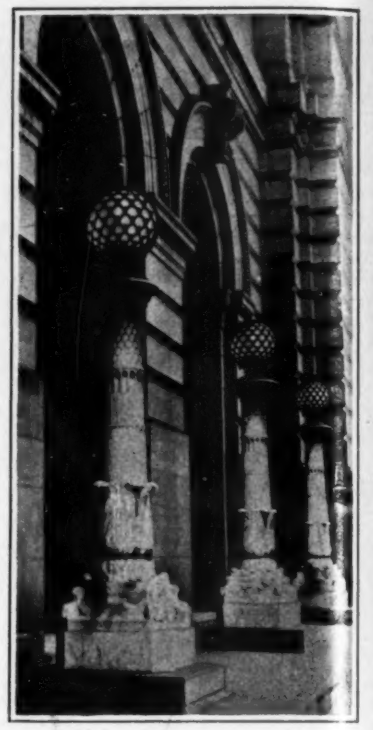
Hand-fired Boilers, Showing Production of Smoke by Careless and Uneconomic Firing. Loss of Efficiency is Probably Between 10 and 15 per cent.

Smoke*

An Industrial Nuisance

By R. C. Benner†

It has been estimated that the smoke nuisance costs Cleveland $6,000,000, Cincinnati $8,000,000, and Chicago $50,000,000 per annum. Herbert W. Wilson, of the United States Geological Survey, is authority for the statement that the country as a whole suffers a loss of over $500,000,000 each year, in damage done to merchandise, defacement of buildings, tarnishing of metals, injury to human life and to plant life, the greatly increased labor and cost of housekeeping, and the losses of manufacturers due to imperfect combustion of coal.



A Besmirched Monument. Carved Lampposts in Front of Carnegie Library, Showing Soot Discoloration.

Recognizing the smoke nuisance to be a civic problem of commanding importance, one of Pittsburgh's most prominent citizens placed $40,000 with Prof. Robert Kennedy Duncan, director of the department of industrial research of the University of Pittsburgh, to make an investigation of the problem. The results detailed in this brief paper are in part those obtained by this research.

Smoke, so appropriately termed the destroyer, one of the most vexatious of modern nusiances, occupies a unique position among the evils which are occasioned by the assembling of man in the modern industrial community. It is regarded by many of our best informed citizens as the greatest municipal problem confronting the soft coal burning cities. A clear atmosphere is a necessity—freedom from a continuous downpour of soot, tar, ash and acid a blessing, a blessing not alone to the community at large, but as well to the producer who dwells in that community. He, in fact, is the fist to profit by the elimination, for the introduction of smoke preventing devices, when properly operated, pays dividends from the start.

PUBLIC SENTIMENT NEEDED TO AID THE ENGINEER.

For the solution of the smoke problem we must depend on the mechanical engineer. To him is already due the credit for the solution of many phases of the problem, and for him remains the task of solving the others, such as round house smoke, smoke from private dwellings, etc. But to make possible the carrying out of his suggestions, the enforced installation of his devices, there must be created a strong and intelligent public sentiment on the economic and sanitary necessity of smoke abatement, and this must come through a widespread campaign of education. In this it is the duty of all civic bodies and persons interested in civic movements to take an active and aggressive part. Societies formed for the specific purpose of smoke abatement alone are fast increasing in numbers and aggressiveness both in this country and abroad.

Generally speaking, soft coal is the only fuel which it is necessary to consider in connection with the smoke problem. It is the smoke-producing fuel par excellence. Other fuels claim our attention in special cases only. They do not enter into the solution of the problem as a whole, for either they are so readily burned without smoke that very little skill and attention is required in their use, or their amount is so small that they form a negligible percentage of the whole.

EARLY EXPERIENCES WITH BITUMINOUS COAL.

Seeking then the root of the evil of modern smoke, it is well to look back over the history of the development of the coal mining industry. As far back as the year 850 A. D. we find mentioned a receipt for "fossil fuel," our present day bituminous coal. This was given by the Abbey of Peterborough to a vendor of this product. But not until the dwellers of the city began to make use of coal as a fuel for heating their houses do we find smoke becoming what might be called a nuisance. Between 1272 and 1307 Edward the First issued a proclamation against the use of coal in London during the sitting of Parliament, fixing the punishment for this offence as death by hanging. The nobility who were wont to assemble in London at that time, dwelling, as they for the most part did, in the pure air of the country, were without doubt easily offended by a dirty atmosphere.

In 1735 Watt, the inventor of the steam engine, took out a patent for a smoke-preventing device, or, as he termed it, "for certain newly improved methods of conducting furnaces or fireplaces for heating, boiling or evaporating water, whereby greater effects are produced from the fuel and smoke is in a great measure prevented or consumed." Even at this early date the fact that smoke prevention meant economy was recognized by the greatest expert of the time—but while his steam engine has come into universal use and has been continually improved upon, his start on the road to smoke abatement has been given little heed. In very truth so little has been done to perfect methods of fuel consumption that even at the present day we find a conservative estimate of the average loss in the Pittsburgh district to be in the neighborhood of 20 per cent of the fuel value of the coal.

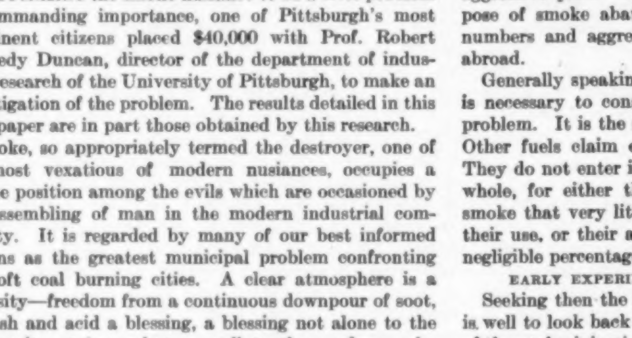
Our much used slogan that "Smoke Signifies Industry and Prosperity" is thus fast losing its force as people are coming to a realization that the conservation of our coal supply is necessary, as well as possible and profitable to every consumer of this article.

In our mechanical engineering survey of Pittsburgh we find, as one might surmise, anything from the most efficient of plants to the crudest of hand-fired furnaces and old two-flue boilers operating under the most wasteful conditions imaginable. We are at present burning in the neighborhood of 15,000,000 tons of coal annually at an average cost of about $1.25 per ton. This means a total expenditure of $19,000,000 for fuel. From these figures the loss would approximate $4,000,000 to the fuel consumer, taking no account whatsoever of the damage done to the people who are forced to dwell in the smoky atmosphere.

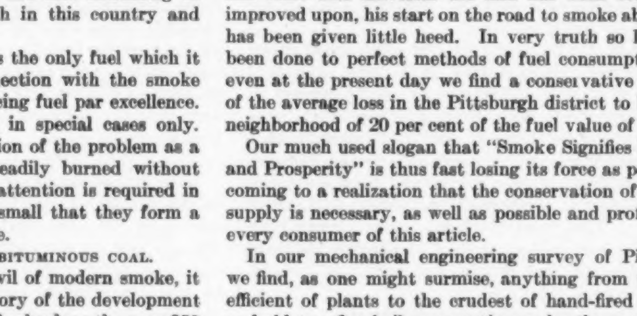
The fact that the losses due to the solid combustible matter in the smoke from the boiler furnaces are very small has been satisfactorily demonstrated. Smoke is therefore an indication of loss rather than a tangible loss in itself. The economy accompanying the proper smokeless combustion of coal is obtained by the complete oxidation of carbon monoxide and other invisible gases such as H, CH_4, etc. Sir Roberts-Austin found as a mean of some forty experiments, that 6 per cent of the coal is lost as soot when the coal is burned in domestic grates, while, on the other hand, Scheurer-Kestner found the loss to be only 0.5 to 0.75 per cent when burned under the boiler, where the temperature of combustion is higher.

* Reproduced from *The Iron Age*.

† Department of Industrial Research, University of Pittsburgh, and chief fellow of Smoke Investigation Commission, Pittsburgh, Pa.



Lower Story of Keenan Building After it Had Been Washed Down. This Story is Cleaned Twice a Year.



Painting Exchange National Bank. This Old Iron Front, One of Pittsburgh's Structures, is Given Two Coats a Year.

Certain types of installations are notorious smokers. Some pieces of apparatus sold by well-known firms are found to make more smoke than the hand-fired furnaces, even when poorly fired. In the operation of any type of installation the fireman must not be left out of consideration, for he, if unskilled, will cause even the best equipped furnace to produce smoke.

By means of a survey, the results of which are to be published in bulletin form, we expect to bring the best practice before those who are not acquainted with the proper methods of smokeless combustion in use in Pittsburgh, and to make it possible for any operator who is producing smoke to put his finger on a plant which is operating smokelessly under nearly the same conditions of load, etc., and in this manner, by comparison, find the remedy with the greatest possible ease.

WHAT SMOKE COSTS PEOPLE WHO DO NOT MAKE IT.

The loss to the coal consumer is one of which an accurate dollar and cent value is readily obtainable. On the other hand, the loss to the dweller in the smoky city is dependable upon so many factors that it is almost impossible to estimate it with any degree of accuracy. We know that it greatly exceeds the loss to the coal consumer —but estimates made up to the present time can scarcely be considered as more than guesses. The accompanying table comprises a few of the most important which we have made. A few scattering figures from our incomplete study of this phase of the subject will appeal to many, more than the complete and total estimate.

Loss per annum London, $26,000,000.

Loss per annum Cleveland, $6,000,000 (equivalent to the annual city taxes; $12 per capita).

Loss per annum Cincinnati, $8,000,000 ($3,000,000 more than the city taxes; $100 per family).

Loss per annum Pittsburgh, $10,000,000 ($20 per capita).

Loss per annum Chicago, $17,000,000.

Loss per annum United States, $500,000,000, or $17 per capita for every man, woman and child living in the large cities.

When you come to a realization that the cleaning bill of some of our office buildings is as high as $75,000 a year, you comprehend what a toll is placed on them. For example, it costs a certain building $320 more a month for window cleaning in Pittsburgh than if the building were situated in either Philadelphia or New York. Thus about 25 per cent of the cleaning expenses of office buildings may be laid to smoke. The lighting bills in office buildings are increased by at least 40 per cent, due to the light being cut off by the smoke in the atmosphere. The sunshine is cut off by about 20 per cent, while the light is diminished 40 per cent in the more smoky sections of the city.

The damage to goods in wholesale, retail and department stores runs as high as $30,000 per year in one store. We have found that it costs from 33 to 50 per cent more to conduct a hospital in Pittsburgh than in other cities. For instance, in the matter of extra cleaning force one hospital could save $3,600 a year, another $1,200. It is necessary for many of the downtown firms to have the entire outside of their buildings washed at least once a year to keep them even respectably clean. One firm thus has an additional expense for this item of $700; another $500.

The laundering expenditure is one third to one half more in Pittsburgh than in smoke free cities. Men claim to wear at least two more shirts and two more collars per week. This means an extra cost of $1.50 per month. Comparable figures for women show an additional cost of $24 each per year. To steam laundries alone are paid a toll of something like $800,000, and this, added to home-washing bills, means a minimum extra expenditure of $1,500,000 annually.

CHEMISTRY OF SOOT.

The source of all this damage is soot, the solid matter given off during incomplete combustion. It consists for the greater part of carbon, mineral matter (ash), tar, moisture, the sulphur acids, and nitrogen compounds, together with occluded gas. A knowledge of the chemical composition and physical properties of soot show why it is the worst possible kind of dirt. The composition and properties vary between the widest limits, depending upon many factors, such as coal, air supply, temperature of the furnace, etc. The accompanying analysis of soot made by Cohen and obtained under different conditions of service, show to a certain extent the effect of these factors.

SOOT FROM A FIRE PLACE.

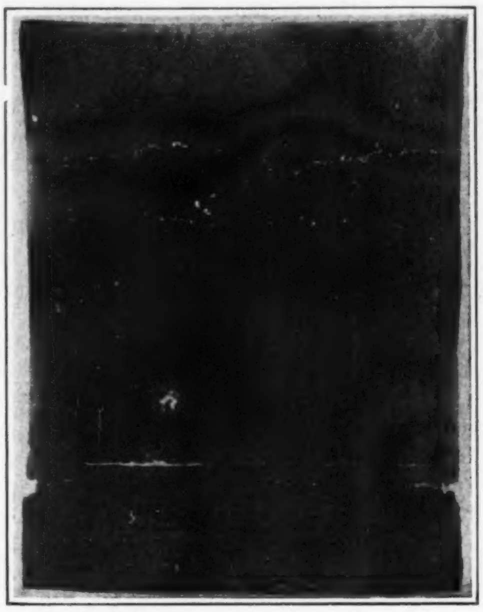
	Original Coal	Soot 5 ft. from grate	Soot 35 ft. from grate
Carbon	76.80	36.45	37.22
Hydrogen	4.90	3.51	3.51
Tar	0.88	34.87	40.38
Ash	1.80	5.09	4.94

It will be noted from the analysis quoted that the percentages of tar and carbon are higher in the soot obtained by burning coal in a fireplace than when it is burned under the boiler. This is due for the most part to the fact that

SOOT RESULTING WITH COAL BURNED UNDER BOILER.

	Original coal	Ordinary grate flue	Boiler Chimney.			
			Bottom	13 ft. from base	70 ft. from base	110 ft. top of chimney
Carbon	69.30	40.50	19.24	16.66	21.80	27.00
Hydrogen	4.89	4.34	2.71	0.86	1.44	1.68
Tar	1.64	25.91	0.09	0.28	0.80	1.14
Ash	8.48	18.16	73.37	75.04	66.04	61.80

the temperature of combustion is much higher in the boiler furnace than in the grate and other domestic installations. The high percentage of ash in the soot from the boiler furnace can be accounted for in the same way.



Piece of Metal Showing Corrosion by Acids in Rain Water.

A Piece of Filter Paper Through Which the Amount of Air Breathed by a Man in One Day Has Been Filtered.

Among the minor constituents of soot the sulphur acids are by far the most important. The amount and kind formed depends upon the factors determining the composition of soot in general. The following analysis of soot by Cohen and Hefford gives an idea of the possible distribution of the sulphur:

Passing out as sulphur gases	71.78	60.00
Absorbed by soot	14.51	11.88
Left behind in the ash	13.71	28.12
	100.00	100.00

The amount of free acid in soot may be quite large, and Cohen and Ruston find free acid to the extent of 1.62 per cent. Arsenic is also frequently found, but only in small percentages, usually less than 0.1 per cent.

THE DAMAGE OF SMOKE TO PROPERTY GENERALLY.

Soot constitutes a serious factor among the many things which impose restrictions upon the architect's use of building materials, the means of expression of his art, a thing with which he has to contend in framing the practical details of construction in his buildings. Then, too, there is the erosion arising from the by-products of coal combustion—another factor which must be taken into consideration if the future appearance of stone buildings is planned for.

We find in smoky districts that it is frequently necessary to modify the design of a building because of the smoke, that all effects which may be attained by undercutting, delicacy of incised line and sharpness of angular forms, must be foregone. The reason is obvious if one uses his eyes in walking through the main streets of Pittsburgh. Skylights cannot be used advantageously, as they soon become coated with the black soot. Drain pipes must be so arranged as to avoid the splashing of rain water on the walls. From the moment that any limestone is exposed to the influence of smoke-polluted atmosphere it begins to deteriorate. Granite and sandstone with a silicious binder form better building materials than either the limestone or sandstone with calcareous binder, which is easily corroded by the acid in the soot and rain. Building materials such as glazed tile, which admits of easy cleaning, are used much more extensively in smoky cities than elsewhere.

Statuary is grievously affected by smoke, and the effect is clearly felt in the case of works of art which form the permanent decoration of a building. This, too, is due to the corrosive action of the sulphuric acid in the atmosphere as well as blackening by soot. The destructive action is, however, seen at its worst in the case of fresco paintings, for there we have as a necessity a surface composed almost wholly of carbonate of lime in a porous condition, to which the dirt clings tenaciously, and from which it is almost impossible to remove.

The effect of soot on paint seems in most cases to be a matter of appearance only. The time which it takes to spoil the paint depends, of course, on the amount of soot in the air, color of paint, tar and acid in the soot. In some cases the paint seems to act as a protective coating, while in others it has a corrosive action destroying the surface gloss and rendering the surface more easily weathered. Some kinds of white paint become soiled by soot much sooner than others. It would seem that those which chalk readily give a new surface by the erosion of the old and hence retain the natural color longer. If the appearance of light-painted surfaces is to be maintained they must be painted once a year.

The most serious effect upon metal work is the corrosion of structural steel. Observations taken in Pittsburgh would seem to show that the soot containing acid is made to adhere to the metals by means of its tar content, in which place it acts with the acid and metal, making corrosion much more rapid.

EFFECT ON VEGETATION.

The smoke continually hanging over our city has a very marked influence in limiting plant growth because of:

1. Reduction of light and heat from the sun.
2. Soot deposits excluding still more light.
3. Tarry deposits blocking the pores of the plants.
4. Acid deposits lowering the vitality of the plants.
5. Free acids falling upon the soil and limiting the activity of the soil organisms, principally those of nitrification.

Certain flowers, such as roses, carnations, etc., will not thrive in Pittsburgh, and therefore many greenhouses have been forced to move further out. In places many of the trees are either injured or entirely killed by the smoke. Then various vegetables grown in different parts of the town in the same soil and except for atmospheric, under the same conditions, prove conclusively the prejudicial influence of smoke on garden crops. For instance, in the case of radishes, only one third the crop was secured; for lettuce, one fourth the crop possible were there no smoke pollution.

SMOKE AND THE WEATHER.

That smoke affects the weather in that it not only cuts off sunlight and daylight, but also increases the duration of fogs and makes the minimum temperature higher, has been proven by our meteorologist, Dr. H. H. Kimball. We have obtained data from the records of the Government weather bureaus at Philadelphia, Williamsport, Harrisburg and Pittsburgh. We have had observations made by chemical and photometrical methods at several stations in Pittsburgh and vicinity, not only in the city itself, but in the clear country air, and we have found:

1. That city fogs are more persistent than country fogs, principally because of the increased density due to the smoke which accumulates in them. As a result, the hours of sunshine are fewer in the city than in the country, and the sunshine that there is, is less intense.

2. There is two or three times the amount of daylight ten miles from the center of Pittsburgh than there is in Pittsburgh itself.

3. Minimum temperatures are markedly higher in cities than in the country, in part, of course, because of city heating, but principally because the smoke acts as a blanket to prevent the escape of heat at night.

4. The amount of soot in the air varies greatly from day to day, depending upon the direction and strength of the wind. That is, we have 20 times the soot in the air on a dark day that we have on a clear, bright day.

EFFECT OF SMOKE ON THE HEALTH.

Dr. Acher of Konigsberg reaches the following conclusions on the relation of smoke to pneumonia and tuberculosis:

1. The death rate from acute lung diseases is by far most frequent in children and old people.

2. The reason for this is that the air is contaminated by smoke, because: First, the death rate occurred in dis-

tricts of industrial character and not on farms; second, in individual places of industry where there is a large quantity of smoke contamination the death rate from acute lung diseases is greater than in places of less contamination; third, the death rate of coal workers from acute lung diseases is much higher (130 per cent) than that of other laborers.

3. Hand in hand with the increase of acute lung diseases there is a decrease in the age of deaths from tuberculosis, i. e., the course of tuberculosis is much shorter.

4. Animal experiments showed that those inhaling smoke died more quickly than those not inhaling smoke.

5. Also, that animals inhaling a moderate quantity of smoke for several weeks, on the inhalation of Aspergillus, developed pneumonia, while the control animals did not.

From our researches in the city of Pittsburgh, Dr. White and Mr. Marcy find that the death rate for pneumonia follows the amount of smoke in the air with great regularity, being high when there is considerable smoke and low when the air is comparatively clear. In case of tuberculosis there seems to be no relation whatsoever between the amount of smoke in the air and the death rate from this disease, owing, perhaps, to its character.

Dr. Klotz finds large amounts of carbon in the lungs of men who have lived in Pittsburgh; 10.6 grammes were found in the lungs of a street peddler 28 years of age. Most of the carbon which becomes lodged in the body occurs in the lungs and lymphatic system near the lungs. Swallowing mucus and any carbon leads to but little absorption and that through the intestinal wall into the surrounding lymphatics. Anthracosis is more prevalent here than in several of the surrounding cities. Carbon, accumulating as dirt on the body, acts as an irritant, more because of the substances which it helps to accumulate than because of the carbon itself. Chimney sweeps get cancer from this cause.

Dr. Holman finds that soot acts as a disinfectant, the moist being more active than the dry. Water seems to dissolve the disinfecting agents in the soot, making them more active. Carbon floating in the air seldom, if ever, carries bacteria unless it has lodged on the ground and is again blown into the air. Soot acts as a very effective blanket, protecting the bacteria and giving them a chance to grow on suitable soil.

Dr. Day finds that diseases of the nose and throat are not appreciably more prevalent in smoky cities, but that they are more severe and harder to cure. This is probably due as much to the cracking of the mucus membrane by the change from the dry atmosphere in the houses to the moist air outside and subsequent irritation by dust and smoke. Singers, on visiting Pittsburgh, usually get "Pittsburgh sore throat," which lasts about seven days, when they become acclimated for the time being. Unfortunately, though, the same thing occurs on every visit to the city.

Thus a strong feeling in favor of smoke abatement is an absolute necessity if the deisred end is to be accomplished. In order to have the facts as a basis on which to bring about an enlightened and active public opinion, this investigation has been conducted. To bring the work of the investigation before the public at large we have organized a staff of lecturers prepared to address civic and business organizations in Pittsburgh and elsewhere; we have secured the co-operation of the press and are publishing in bulletin form the results of our inquiry.

How to Make an Electroscope*

A Comparatively Easy Task When You Know the Way

By Charles E. Benham

To make a very sensitive aluminium-leaf electroscope is a simple enough matter if one or two useful hints are attended to. Chief among these is one as to the way to cut the foil. It is best done by placing the leaf between two pieces of writing-paper and cutting all together with a sharp pair of scissors. Beginners nearly always have trouble here because they find that the strip thus cut adheres to the cut edges of the paper, and in trying to separate them they get the foil kinked or broken. A very simple expedient entirely removes the difficulty. When the strip has stuck to the edges of the paper do not try to separate them, but lay them, foil uppermost, on a smooth surface. On the top lay carefully a well-warmed piece of smooth writing-paper. Hold it firmly at one edge to keep it from shifting and pass a dry hand quite lightly over it. This will electrify it, and on lifting it the foil will be found adhering to it. When the paper is cool the leaf will be found to be quite loose and free. A strip of clear celluloid may be used instead of warmed paper, and has the advantage of transparency. It should only be slightly electrified; a single sweep of one dry finger is generally enough.

The next difficulty occurs in mounting the strips, and here it depends upon whether two leaves are required, as in the original form, or only one leaf, to be repelled by a fixed strip of metal, as in the form often used nowadays.

If two foils are required, coat with tinfoil two strips of thin card about an inch long and the width of the foil. Having the two foils lying straight on the sheet of paper, lay the two card strips one on each foil, so as to cover about ⅛ inch, the lower side of the card having been first smeared with the merest trace of gum or paste. Lay the cards down very carefully, exactly in line with the foil. They can now be lifted and placed face to face, insuring a perfectly parallel pair of strips.

If only one foil is used, the metal strip, with a light touch of adhesive near the upper part, is brought down on the foil and lifted. A very sensitive single-leaf electroscope is produced by attaching the foil, not to the metal strip itself, but to a little flat pellet of paraffin-wax attached near the top of the metal. The foil then hangs insulated, reducing the capacity to a minimum.

The thorough insulation of the conducting-wire that supports the leaves is most important, and is well insured by using sulphur. A stout wire having been passed centrally through the bottom of a cardboard pill-box, melted sulphur is poured in from a ladle. Grease the bottom of the box, so that it may be easily detached when the sulphur has set, and before pouring in the sulphur make a few notches in the wire where the sulphur is to surround it, so that it does not afterward slip. The cylindrical part of the box should not be removed. The wire should be of such length as to protrude above and below the sulphur an inch or so. The lower end of the wire should first have been soldered to a short strip of thin sheet lead, which can afterward be bent back on itself twice, like a horizontal ∽. The card strips bearing the aluminium leaves are placed in the fold of the lead, and a nip with the pliers holds them firmly in place. In the same way the lead can be made to grip the top of the metal strip that bears the single leaf, if that form of electroscope is preferred. It is always best to have the leaves and their attachments conveniently removable, so as to allow of renewal.

A perforated brass ball is placed as a terminal at the end of the wire above the sulphur, and this should also be removable, so as to allow of the substitution of a condensing-plate for more delicate measurements.

This plate is a disk of brass or copper with a little tube of brass or copper ½ inch long fixed vertically and centrally from its lower side. The tube may be easily made by rolling a strip of thin copper neatly round the wire and soldering it along the joint. The upper surface of the brass plate should be well planed and coated with shellac varnish. A similar disk, varnished on its lower surface, and having a metal or wooden handle fixed vertically to the center of its upper side, completes the condenser.

The pill-box of sulphur must be fixed vertically in the top of an appropriate case—a chalk box is a convenient thing for the purpose, the sliding lid being replaced by glass, which forms the front side of the electroscope, and the interior of the box being lined with white cartridge paper. Cut a circular hole in the narrow end of the box (the top of the electroscope) to fit the pill-box, and fix it in position with glue.

It should be noted that the end of the wire that protruded through the bottom of the pill-box when the sulphur was poured in should be the one that supports the ball or disk, because the sulphur will have a smoother surface at this end, and it is neater to have the smooth surface uppermost. It is an advantage to have two upright metal strips one each side of the aluminium leaves, to increase their sensitiveness and to allow them to discharge when they diverge beyond a certain limit. These discharging strips are best made of sheet lead well blackleaded. No other surface is so free from the tendency to adhere when the leaves touch it. Even the blackleaded surface will occasionally hold the leaf, especially in damp weather. A tap upon the side of the box will, however, at once release the foil. The lead strips may be either fixed to the sides of the box, or, better still, mounted on metal rods that pass through the sides, and can be adjusted to any desired distance from the foils. Of course, with the single-leaf form only one will be required.

To use the condenser, put the top plate on and connect this to earth by a thin wire, that is, to the box, for we are dealing with high potentials, and wood is a perfect enough conductor. Let a thin wire connected with the socket of the lower plate project horizontally a few inches as a conductor for the charge to be tested. The minutest charge given to this will manifest itself by a wide divergence of the leaves when the top plate is lifted by its handle.

As an example of the extreme delicacy of the condensing electroscope, the following interesting and little-known experiment may be tried: Place the instrument near the window of an upper room, leaving the window a little open, so that the outer air flows in. Connect the electroscope (with its condensing plate earth) to a lighted lamp (flame) standing in the draught from the window on a well-insulated stand, such as a cake of paraffin. Withdraw the electroscope from the lamp and then lift the top condensing plate, and the leaves will diverge with electricity from the atmosphere outside. A radio-active surface will answer instead of a lamp, and in this way the electrical condition of the atmosphere may be tested at any time, without any outside connections.

The aluminium foil may be obtained through any chemist. It is not quite so thin as gold leaf, but being lighter as a metal it is practically as sensitive and much more easy to manipulate. Dutch metal can be employed, but it is not so sensitive.

* Reproduced from the *English Mechanic and World of Science.*

Ocean Temperatures Along the West Coast of North America

Dr. G. F. McEwen, Physicist of the Marine Biological Station of San Diego, has carried out researches on the distribution of ocean temperatures along the west coast of our continent, the results of which are published in the *Internationale Revue der gesamten Hydrobiologie und Hydrographie* and are summarized by the author as follows:

Numerous observations extending over a long period have established the presence of abnormally cold surface water contiguous to the west coast of North America, but a diversity of conflicting theories have been proposed by various writers to account for the phenomenon.

The conclusions reached by different investigators may be summarized as follows:

1. A cold arctic current flows south along the coast from the polar regions.

2. The Japan current, because of its passage through high latitudes, becomes cooled, and as it flows south along the coast of the United States, appears as a cold stream because its temperature corresponds to the normal value prevailing in higher latitudes.

3. The accumulation of water in the south polar region causes an excess of pressure which drives the cold bottom water northward with an increasing velocity owing to the diminishing distance across the Pacific, till when it reaches the latitude of Sitka, Alaska, owing to the deflecting force due to the earth's rotation it is driven up the continental slope and flows south as a cold current, since it has no other outlet.

4. The coldest water is located about 800 miles south of Sitka in the summer time, and areas of alternately warm and cold water are distributed in an irregular manner all along the coast. But from each of the previous theories, owing to the continual increase in the heating effect of the sun toward the south, a continuous rise in temperature would accompany a decrease of latitude. Therefore, the low temperature must result from an upwelling of cold bottom water from the adjacent ocean depths. A general eastward drift of the ocean water extending to the bottom is assumed to result from the continued action of the winds, consequently the cold bottom water is driven up the continental slope, most of it reaching the surface at Cape Mendocino (the coldest region). The irregularities in temperature distribution are due to the effects of submarine valleys and differences in the slope of the ocean bottom.

The above theories were based on hypothetical causes, which in some cases were not verified except by the general qualitative agreement of the deductions with the particular observations considered, and the theory of oceanic circulation proposed in 1878 by Zöppritz was widely used. No attempt was made to explain

the seasonal fluctuation in ocean temperature distribution.

Before going on with the conclusions regarding the Pacific coast region it will be necessary to consider general theories of oceanic circulation. A recent one due to Ekman differs from that of Zöppritz, in that no assumption as to regular flow in plane layers is used as a basis, but a virtual value of the coefficient of viscosity, allowing for the actual turbulent motion of the water is used, and the deflecting force due to earth's rotation is also introduced. Many results of Zöppritz's theory are inconsistent with observations, while those of Ekman's theory are in harmony with experience. Most results of the two theories differ widely.

From Ekman's theory it follows that there must be an upwelling of the cold bottom water along most of the coast of North America owing to the action of the observed winds, and in the present paper, assuming the low temperature to be due entirely to cold bottom water upwelling and mixing with the surface water a theoretical formula was derived by which the abnormally low temperatures of any region could be computed for each month of the year. A very satisfactory agreement with observations was obtained, though the temperature reduction below the normal varied from 0 degrees to 8 degrees.

In general the theory shows that the area affected and the magnitude of the temperature reduction and its distribution vary with the depth of the water, the slope of the bottom, the velocity of the winds, the portion of the surface over which they extend and the steadiness of the winds.

To give an idea of the peculiarities of temperature distribution that have been accounted for by means of these principles the following results of observation are enumerated:

The cooling effect of the upwelling water extends to a distance of 600 kilometers from the coast off Cape Mendocino, latitude 40 degrees and increases to a distance of 2,100 kilometers from the shore off San Diego, latitude 32 degrees 45 minutes.

The temperature reduction in the summer is a minimum off San Diego and a maximum off Cape Mendocino where the coldest surface water is found.

Temperatures as low as 14 deg. C in August have been found in certain limited areas near the coast south of latitude 35 degrees, while the value 18 deg. C prevailed in the surrounding water a few miles away, both north and south.

Considering the complexity of the phenomena, the agreement between the theory and the observations has been very satisfactory, and judging from the results already obtained it would be profitable to carry on a more detailed and quantitative investigation following the lines suggested in the present paper.

Absorption of Light in Space*

Is There An Absorbing Medium in Interstellar Space?

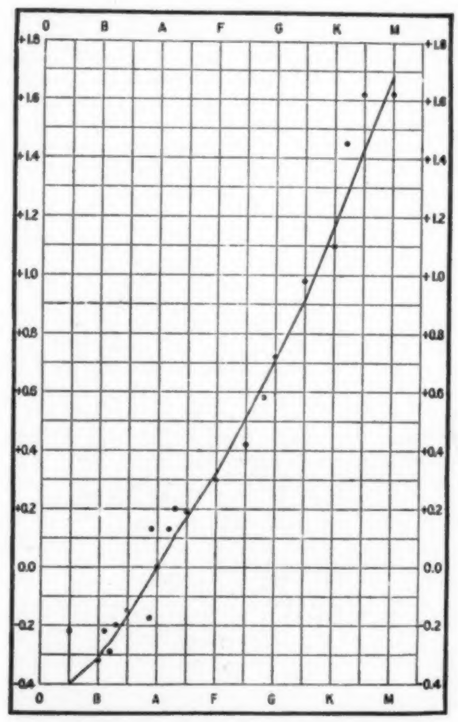
By Edward S. King

SPACE, as well as time appears to be illimitable and eternal. Astronomical research simply pushes the boundaries of human knowledge a little further into what was previously unknown. One of the interesting problems relating to space is whether the light from the stars suffers any diminution in traversing the immense distances before reaching our atmosphere.

The data on which my work has been based consisted in a series of photographic magnitudes of the brighter stars, accurately determined. I found by comparing these magnitudes with the visual magnitudes from the Revised Harvard Photometry, that the differences, when plotted according to the class of spectrum, fell on a curve which was almost a straight line. This is shown in the accompanying figure. The values represent the individual cases so well that we may obtain photographic magnitudes with little error by simply adding them to the magnitudes found visually.

On an average, stars of class B are 0.32 magnitudes brighter, while stars of class M are 1.62 magnitudes fainter photographically than visually. This indicates that stars of class M are redder than those of class B. Thus it is seen that the stars, when arranged, as they are, according to the class of spectrum, have varying degrees of redness. Now, the principal part of this redness is due to causes inherent in the star, but a portion may be due to differences in distance. If space is not an absolute void but is filled with dust or fine meteoric matter, such matter must scatter the light. As the blue rays would suffer more than the red rays, the effect would tend to make the more distant stars appear redder. It is, therefore, assumed that greater redness corresponds to greater distance. If, from the differences between the photographic and visual magnitudes, we subtract the average difference for the class of spectrum, this deviation from the average will represent the degree of redness due to other than inherent causes.

The first step was to group the deviations for the several stars according to the parallaxes. The result



Photographic Magnitude Minus Visual Magnitude. Plotted Against Spectral Class.

showed that the stars having smaller parallax, and consequently having the greater distance were redder. As the next step, all stars having a parallax of 0".030 or smaller were rejected from our list. This left 26 stars. Following Kapteyn's work in No. 42 of the "Contributions from the Mount Wilson Solar Observatory," the difference between the photographic and the visual magnitude may be considered as the sum of four quantities: (1) The inherent redness of the star as indicated by the average difference for the class of spectrum; (2) the redness dependent on the apparent magnitude; (3) the redness dependent on the absolute magnitude, and (4) the redness dependent on distance. The unit of distance for computation was taken for the value of parallax equal to 0".1, or the distance measured by 32.6 light-years. To eliminate (2) a grouping of the deviations was made according to magnitude. As the result, the fainter stars, which are probably more distant, appeared very slightly redder. The other two factors were reduced by the method of least squares. The result indicated a loss of 0.0377 magnitudes for the photographic rays, and 0.0184 magnitudes for the visual rays, while traversing the unit of distance.

These figures having been derived from 26 stars, it was thought best to improve the data by applying the method to other stars. Accordingly, a supplementary list of 22 stars was observed. The procedure was in all respects that followed previously. The resulting values had the same sign, indicating absorption by greater redness of the more distant stars, but were somewhat larger than before.

If all the stars were of the same class of spectrum, the problem would be much easier. In examining the 48 stars thus far measured, the several classes of spectrum were found to have from 4 to 8 stars each. A separate reduction was made from each of these classes, which in all cases showed greater redness corresponding to greater distance.

Another improvement in the data was effected by selecting from both lists only those stars having the parallax most accurately determined. This reduced the number of stars to 28. The reduction of these gave values identical with the results found previously from the 26 stars. Thus, the indications from this work all point to the presence of an absorbing medium in space, or some factor which produces effects similar to absorption, by making the more distant stars appear redder.

*Reproduced from *Popular Astronomy*.

Eyesight and Typography*

THIS report of the British Association Committee on the influence of school-books upon eyesight is full of interest. Its value depends chiefly upon the report of the oculist subcommittee, which was composed of Messrs. Priestley Smith, H. Eason and N. Bishop Harman. Advice upon the technical and trade aspects of printing was given by competent experts.

The subcommittee's report is valuable from the immediate point of view of school-books and also from the point of view of the reading of printed matter in general. Considering the enormous importance of reading and writing to the general public and the large place they occupy in daily life, it is remarkable that so little attention has hitherto been devoted to the physiological and hygienic features of the subject. With few exceptions the report recommends the principles advocated by Javal, and the authors have, perhaps wisely, refrained from any experimental researches on their own account. The subject is full of complications, physiological and psychological, and the recommendations made are as good as can be expected in the present state of knowledge.

At the outset of the section of the hygienic requirements the right note is struck in emphasizing the fact that the reader recognizes whole words and phrases at a glance. This statement expresses the essential difficulty of the scientific investigation and regulation of printing. Too much stress cannot be laid upon the fact that the canons of *visibility* of individual letters do not apply directly to the far more complex problem of the *legibility* of letter groups in words and phrases. It is rightly pointed out that the upper half of a word or letter is usually more important for perception than the lower half. We would emphasize the point more strongly. It is the fundamental factor in legibility, as is easily proved by reading with the lower half of the line covered by a card. Hence we think that the suggestion made to give more distinctive character to the lower half of a larger proportion of letters is unsound.

The general evolution in the shapes of printed letters has been in the direction of increasing the predominant features of the upper halves, so that more letters extend above the line than below, the extension above the line has increased, while that below has been curtailed, and so on. These tendencies are in favor of legibility and should not in our opinion be tampered with. For the same reason we are astonished at the statement that "uncial Greek may be recommended as being easy to read (see supplement)." The supplement gives two examples, one in 12-point Porson Greek, the other in uncial Greek on long primer body. A glance suffices to show that the former is much more legible.

Owing to the complexity of the correlation of the physiological and psychological factors in reading, such details as the best dimensions of letters and spacing, length of lines and their separation, and so on, are at present matters of compromise. The committee does not give any explicit scientific reasons for the faith that it has, but the typographical table and the rules laid down are eminently sensible. The small type used in Bible and prayer-books is more than a matter of regret; we should like to have seen it more severely condemned. The remarks on the thorny question of atlases are very good.

We hope that this report will have a widespread influence. It contains much sound advice not only for those who deal in school-books, but for all authors and publishers.

*Report on the Influence of School-books upon Eyesight by a Committee of the British Association, presented at the Dundee Meeting, 1912. Copies obtainable from the British Association, Burlington House, London, W. Price 4d. Review taken from *Nature*.

Morane Saulnier 100 Horse-power War Monoplane.

The 50 Horse-power Cross-country Model (Non-rigid Chassis).

The Morane-Saulnier Monoplane

The Holder of the Height Record—17,880 Feet

By John Jay Ide

WITH the exception of the Nieuport, the Borel-Morane monoplane (described in the SCIENTIFIC AMERICAN SUPPLEMENT of June 24th, 1911) proved the greatest revelation of the 1911 season. It won the Paris-Madrid race; was third in the Paris-Rome contest; made the fastest time over the majority of stages in the Circuit of Europe, being fourth in the general classification; and gained second place in the Circuit of Britain. When, therefore, it was announced late in the summer that Messieurs Leon Morane and Ralph Saulnier had separated from the Borel firm, the appearance of the latest product of these two engineers was awaited with interest.

The Morane-Saulnier aeroplane was first shown to the public at the Paris Aeronautic Salon in December, 1911. In all, four types were exhibited: A school machine, a two-seated military model, a racer, and an all-steel war monoplane. The last two are especially interesting, incorporating many excellent and practical ideas. The scale drawings and the following description refer to the racer in its present form, which differs in several respects from the machine shown at the Salon in 1911.

The fuselage, roughly stream line in shape, is covered throughout its entire length by fabric in order to minimize head resistance. As in many of the latest machines, only the head of the pilot is exposed above the sides of the cockpit. The edge of this cockpit is upholstered in order to avoid injury to the helmsman in case he is thrown against it by a violent landing.

The controls are similar to those of the Blériot and consist of a foot-tiller and a lever on the upper extremity of which a hand-wheel is mounted. The lever is moved forward and backward to operate the elevator and the wheel is rotated to warp the wings. The foot-tiller governs the rudder.

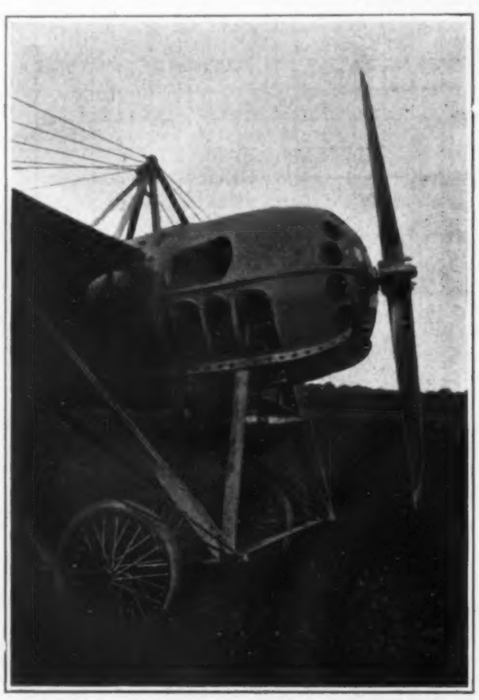
The motor, one of the new eighty horse power Gnômes of 124 × 140 millimeters bore and stroke, is mounted "port-a-faux;" that is, it protrudes from the front of the fuselage and is not supported on both sides of the crank case. The engine casing is extremely well designed, protecting the pilot perfectly from oil and exhaust products and eliminating much of the resistance presented to forward advance by the rapidly revolving motor. The cooling is not interfered with, as a large segment of the motor is directly exposed to the air. The Chauvière tractor screw is of eight feet six inches diameter and six feet pitch.

As in the Borel, the wings have no dihedral angle and the entering edge is shorter than the trailing edge. By this arrangement marginal losses are avoided and the warping is made more effective. The wings taper considerably toward the outer extremities.

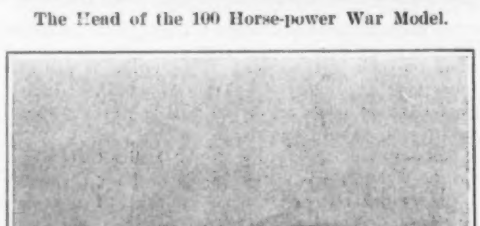
The tail resembles that of the Borel which, in turn, was copied from the Blériot XI. A fixed monoplane surface acting as stabilizer is flanked by the twin elevator ailerons. The stabilizer is of the lifting type although its curvature is very slight. As the lifting tail presents more head resistance than one of the purely flat non-lifting type it would seem that the latter is more suitable for a machine of this kind. The construction of the tail is sufficiently strong to render unnecessary bracing wires and tubes. The control connections are placed in the interior of the fuselage so that the network of wires which still envelops the rear construction of some aeroplanes is here totally absent.

The undercarriage is constructed of oval section steel tubing. The axle connecting the two landing wheels is held in place by four struts. Two additional members form a central inverted triangle to the lower apex of which the staying cables of the front wing spars are connected.

The landing gear has been the target for a great deal of criticism as, apart from the resilience of the pneumatic tires with which the wheels are shod, no means whatever are provided for shock absorbing. Buckling of wheels and bending of tubes have been freely predicted as consequences of the suppression of shock absorbing devices. The gloomy prophecies of the critics, however, have not been fulfilled. A whole season's use of the rigid landing gear has demonstrated that it is perfectly satisfactory. An explanation of this may be found in the fact that the model in which it is employed has been handled almost exclusively by experts. In the two seater, designed for more general use, the non-rigid chassis has been adopted. There is a small skid at the rear to protect the tail.



The Head of the 100 Horse-power War Model.



The 50 Horse-power Cross-country Model in Flight.

Some particulars of the Morane-Saulnier single seater are as follows: Area of main plane, 145 square feet; area of fixed-tail plane, 8 square feet; area of rudder 5¾ square feet; weight (empty), 660 pounds; price (for delivery in France) complete with 80 horse-power Gnôme, 31,000 francs ($6,200)

. . . .

The Morane-Saulnier was first tested at Villacoublay by Védrines who attained a speed of 78 miles per hour with a Gnôme of only 50 horse-power. On Jan. 24th, 1912, at Pau, Tabuteau, with a similar machine, broke the world's record for 200, 250 and 300 kilometers, and for two and three hours, which had stood since 1910 to the credit of Aubrun and Bournique. In two hours, 205 kilometers (127 miles) and in three hours, 316 kilometers (196.4 miles) were made. This remarkable flight lasted for three hours and five minutes during which time 200 miles were covered. A month later Tabuteau broke his own record for two hours, covering in that time 227 kilometers (141 miles), and on March 1st he broke it again with 234 kilometers (145.4 miles) also reducing his time for 250 kilometers.

On March 11th Tabuteau succeeded in making the journey from Pau to Paris in one day, breaking all cross-country records. The 450 miles were covered in four hours and fifty-five minutes flying time giving an average speed of 90 miles an hour. Two stops were made, one at Poitiers and the other, caused by a faulty plug, at Etampes. Villacoublay, one of the flying grounds near Paris, was the scene of the finish of this remarkable flight.

Tabuteau became the first holder of the Deutsch de la Meurthe Cup by flying a 125-mile circuit at 70 miles an hour on April 27th. A few days later, however, Helen, on a 70 horse-power Nieuport, beat his speed by more than the requisite one tenth, making 79 miles an hour over the circuit.

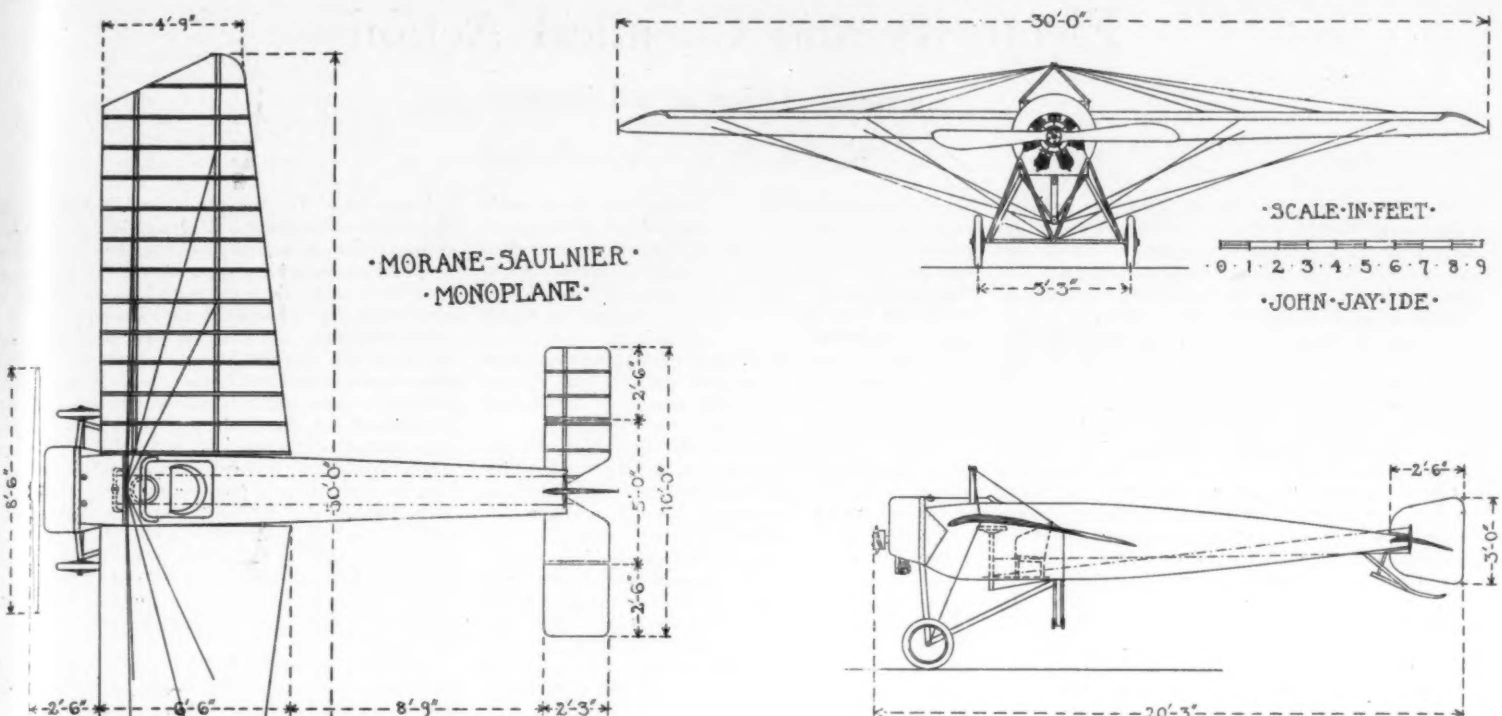
On April 30th Bedel won the third Pommery Prize by making the journey from Villacoublay to Biarritz in a day on a Morane machine. This hitherto unknown pilot covered the 468 miles with three stops in five hours and sixteen minutes flying time.

In the Grand Prix of the Aéro Club de France, held over the Anjou Circuit, June 16th and 17th, several Moranes were entered, but Bedel and Brindejonc des Moulinais were the only pilots of this make who actually started. Bedel, on a 50 horse-power machine was eliminated at once, but Brindejonc, who started three hours late, was the only competitor besides Garros, the winner, to complete the three rounds of the course required on the first day. Unfortunately Brindejonc arrived four minutes after the closing of the control and was thus debarred from further participation in the race.

In the Prix d' Anjou, held June 17th, Bobba and Brindejonc were the first and second to finish, but were classed second and third, respectively, the first prize being awarded to Espanet on an 80 horse-power Nieuport for having carried a passenger which, under the rules, reduced his time by one sixth. Bobba's Morane had only a 50 horse-power Gnôme, but Brindejonc's machine had one of the 80 horse-power Gnômes built for the Grand Prix.

During the month of August Brindejonc made two attempts to capture the fourth Pommery Prize by a flight from Paris to Berlin in one day. In both cases, however, he was compelled to descend short of his goal, landing on August 8th at Attendorn in Germany and on August 29th at Rude in Luxemburg. The fourth Pommery Prize was won by Daucourt who, on a Borel, made the journey between Valenciennes and Biarritz (532.5 miles) in one day.

The most sensational feat accomplished on a Morane-Saulnier was the breaking of the height record on Septem-



ber 17th last. In the effort to eclipse the mark of 5,000 meters (16,400 feet) set by Garros on a Blériot a few days previously, Legagneaux drove his 80 horse-power single seater 5,450 meters (17,880 feet) above the surface of the earth. In the presence of the constructors and several Aero Club officials, he rose from Issy-les-Moulineaux at 11:53 A. M. 1,000 meters (3,280 feet) was reached in 2 minutes 30 seconds; 2,000 meters (6,560 feet) in 7 minutes 30 seconds; 3,000 meters (9,840 feet) in 12 minutes; 4,000 meters (13,120 feet) in 20 minutes; 5,000 meters in 35 minutes; and 5,650 meters in 45 minutes. Legagneaux had prepared to inhale oxygen when at this high altitude, but the mouthpiece was not properly adjusted and he did not use any. He landed promptly at one o'clock at Villacoublay, the time and place he had set for his descent before leaving Issy.

This final exploit gives evidence once more of the good qualities of the Morane so often confirmed by its exhibitions of speed and endurance in the long-distance cross-country trips accomplished during the season. To its rapidity, stability and strength, due to fine design and careful construction, we must now add an altogether exceptional climbing power.

. . . .

The Morane-Saulnier war monoplane shown at the Salon of 1911 in an uncompleted state was, so far as known, never finished. Another machine modeled along similar lines was built during the summer and tested at Villacoublay. The net result of the experiments held with it has been to slightly reduce the length of the body.

The fuselage accommodating a pilot and passenger in tandem is of torpedo form and constructed throughout of sheet steel. From its blunt nose, which is well ventilated for the cooling of the motor, to a point to the rear of the pilot's seat, this body is of circular section, but from that point to the tail it flattens out horizontally. Several perforated steel ribs reinforce the fore part of the body.

In the Salon machine the framework of the wings was entirely of steel tubes, the joints being made by acetylene welding. The wing section was a modification of the Phillips type as shown on the Nieuport and its copy, the Hanriot, but without the reverse curve at the rear. In the machine tested last summer, however, the generally accepted type of wing section was used.

The wings do not taper from root to tip as in the racer, but preserve the same chord throughout their length except at the extremities, which have an oblique shape to avoid marginal losses and to render the warping more powerful. The front spar of each wing is trussed by six cables, three to the *cabane* and three to the landing gear. To each rear spar run six warping wires, three from the *cabane* and three from the pylone.

The empennage is exactly similar to that of the racer and therefore needs no description. The steel landing gear is of great strength, being composed entirely of elliptical section steel tubes. The two sets of twin wheels are attached to the rudimentary skids by rubber bands as in the Farman biplane. The skids are kept from spreading by tension members forward and aft of the wheels. There is no common axle uniting the pairs of wheels in this monoplane.

Some particulars of the Morane war monoplane are as follows: Length, 30 feet 3 inches; span, 42 feet 8 inches; wing area, 290 square feet. The Chauvière tractor screw of 8 feet 6 inches diameter is driven by a fourteen-cylinder Gnôme motor of 100 horse-power.

A Mechanical Ice Saw

There is no department of industry, either on a large scale or for domestic operations, which has not been invaded by electricity. Electric cars convey us from our home to our work, whether for comparatively short distances through the streets of the city or over longer stretches, where, until but a few years ago, the steam-drawn train was the rule. Electricity lights our homes, supplies heat for various purposes, runs our fans in summer, etc., and the list might be extended indefinitely. Occasionally we hear of an application which bears some novel feature about it. An example of this kind is shown in our illustration, which depicts a saw in service at an ice plant in Buffalo, N. Y., and driven by an alternating current induction motor. It was installed for the purpose of cutting the large cakes of ice, as they come from the machine, into smaller blocks for convenient handling. The saw is hung from a framing formed of I-beams and traveling upon rollers over guide rails. The circular saw can be moved across the cake of ice by the aid of a hand wheel and chain. The saw is run by an electric motor, developing from two to three horse-power and operating at 1,500 revolutions per minute, the saw itself rotating at a somewhat lower speed. The current is supplied to the motor through the hanging flexible cable seen on the right in our illustration, and connected with the 220-volt light and power circuit of the building. Needless to say that this mechanical saw does the work of several men with much economy of time and expense, and we have here another example of the universal applicability and remarkable adaptability of electricity in all branches of manufacture and industry. So much has the use of this force of nature spread, that it is difficult to realize how indispensable it has become and just how we should be placed if, for some reason or other, we suddenly were forced to do without this valuable auxiliary to which we have become so accustomed.

Ice Saw Driven by an Alternating Current Motor.

Electricity and Chemical Action*

Chemical Action at a Distance

By Prof. Harry C. Jones†

The reciprocal transformations of intrinsic and electrical energy constitute the subject matter of electrochemistry. That intrinsic energy can be transformed into electrical is exemplified in the primary cell. The Daniell cell is a machine for converting a part of the intrinsic energy of zinc into electrical energy.

CONVERSION OF ELECTRICAL INTO INTRINSIC ENERGY.

That electrical energy can be converted into intrinsic is shown in every act of electrolysis of, say a fused salt. When an electric current is passed through fused sodium chloride, some of the electrical energy disappears, and a part of that which disappears is converted into intrinsic energy of sodium and of chlorine. The intrinsic energy of the sodium and of the chlorine is raised to the level at which it exists in these substances in the elementary condition. The elements sodium and chlorine are reformed, the one at the cathode and the other at the anode, each with its original quantity and intensity or potential of intrinsic energy.

It should be said in advance that the developments in the field of electrochemistry during the last 25 years have been nothing less than marvelous. Indeed, a quarter of a century ago, the whole subject of electrochemistry was literally in its infancy. During this time entirely new electrochemical methods have been discovered and devised for separating the metals, not only from one another, but from their ores. The art of electrometallurgy has come into such prominence that many of the most valuable metals are now obtained almost exclusively by the electrical method. A new branch of quantitative analysis has grown up around the electric methods of effecting these separations.

ELECTROLYSIS OF THE ELEMENTARY GASES.

The elementary gases, oxygen, hydrogen, chlorine, etc., have been known for a long time to contain two atoms in their molecules. One atom of an elementary gas was, however, looked upon as just like any other atom of that element.

Sir J. J. Thomson showed that this was not the case. He introduced hydrogen into a glass tube into whose ends platinum electrodes were sealed, and sparked the gas. Across the center of the tube a loosely fitting septum of aluminum was placed. After sparking the gas for some time, its spectrum was taken on the two sides of the alumininum septum. On one side the green line of hydrogen came out strong and the red line weak; while on the other side of the septum the red line came out strong and the green line weak.

This shows that the molecular hydrogen had been broken down into a positively charged atom and a negatively charged atom of hydrogen. One of these gives the strong green line and the other the strong red line.

Similar results were obtained with chlorine, so that it now seems fairly certain that in diatomic molecules of the elements in general we have a positive atom and a negative atom, and these two atoms have, of course, somewhat different properties.

Thomson went farther and showed that when the compound methane, CH_4, is electrolyzed, the carbon went toward one pole and the hydrogen toward the other. The hydrogen atoms in methane can be readily replaced, one at a time, by chlorine, giving monchlormethane, CH_3Cl; dichlormethane, CH_2Cl_2; trichlormethane, $CHCl_3$; and finally tetrachlormethane, CCl_4.

AN ION NOT ALWAYS CHARGED WITH THE SAME SIGN.

When these compounds were electrolyzed, the chlorine went not to the positive poles, as it would have done if it were negatively charged, but to the negative pole—to the same pole that the positive hydrogen which it replaced went; showing that the chlorine which replaced the positive hydrogen was positive, and not negative, as it had hitherto been supposed that chlorine always is. The bearing of this experiment on one of the most important reactions known to chemists ought to be obvious. The hydrogen in methane is replaced or substituted by chlorine—positive hydrogen by positive chlorine. Now substitution is one of the most important and general of chemical reactions. When zinc is treated with sulphuric acid the hydrogen of the acid is replaced by the zinc. In what does this act really consist? A transference of the positive electrical charge from the hydrogen ion which has it but holds it loosely, to the zinc which takes it and holds it more firmly than the hydrogen.

Since the substituting atom or group, from Thomson's work, always has the same charge as the thing substituted in the molecule, it follows that this most important chemical reaction is purely an electrical act, a transference of the electrical charge from the constituent of the molecule which holds it weakly, to something which holds it more firmly and therefore takes it. The constituent which has lost the charge leaves the molecule, since there is nothing to retain it in the molecule, while the atom or group which has taken the charge is consequently drawn into the molecule.

Probably all substitution in chemistry, organic or inorganic, is then purely an electrical act.

CONDUCTIVITY OF ELECTROLYTES A MEASURE OF DISSOCIATION.

We may assume that the reader is familiar with the theory of electrolytic dissociation, and the way in which molecules of acids, bases and salts break down into ions. It has been shown that the presence of ions is necessary for chemical action, and that chemical action is a maximum where there are a maximum number of ions present.

It is obviously a matter of fundamental importance to determine in any case the magnitude of the dissociation of any solution of any concentration of any given electrolyte. A simple method, and one that is fairly accurate, was worked out by the distinguished physicist, Kohlrausch, and every one must be familiar with the essential features of this method.

If a solution of any given substance is not dissociated at all, it means that it does not conduct the current, and, conversely, if a solution does not conduct the current, it means that it is not dissociated.

We have maximum conductivity when we have maximum ionization. This statement must be clearly understood or it will lead to confusion. In order to produce complete dissociation we must have the solution very dilute. The above statement does not mean that a very dilute solution of an acid, base, or salt conducts the current better than a more concentrated solution, but it does mean that when the conductivity of a dilute solution is divided by the concentration expressed decimally, the resulting conductivity is greater than that of a more concentrated solution.

This holds up to a certain dilution, beyond which the conductivity does not further increase, no matter how much the dilution is increased. When this maximum, constant value is reached, it means that the dissociation of the solution is complete.

When the actual conductivity is divided by the concentration expressed decimally, the result is known as the molecular conductivity.

To obtain the dissociation of any solution of any electrolyte, it is only necessary to divide the molecular conductivity of the dilution in question by the maximum, constant value of the molecular conductivity for the substance under investigation.

Space will not permit of a discussion of the details of the method, such as the units used, the concentrations employed, the apparatus required and the results obtained. For these details see "Elements of Physical Chemistry," fourth edition, pp. 377 to 419.

SULPHURIC BY NO MEANS THE STRONGEST ACID.

A few results will, however, be mentioned. Hydrochloric, hydrobromic and nitric are among the strongest acids. Sulphuric acid at ordinary dilutions is only a little more than half as strong as those acids just mentioned. This may be a surprising result, since sulphuric acid has generally been regarded as one of the very strongest acids. The reasons for this are obvious after a moment's reflection. Sulphuric acid has a comparatively high boiling point. It is, therefore, not appreciably volatile at ordinary temperatures. Further, sulphuric acid has great power to combine with water.

Sulphuric acid, having a high boiling point, displaces acids with lower boiling points from their salts, e. g. hydrochloric acid from chlorides; and for this reason was regarded as a stronger acid than hydrochloric. This fact shows absolutely nothing as to the relative strengths of the two acids in question; the action is simply a result of their relative boiling points. Boric acid, one of the weakest acids known, will displace sulphuric acid from sulphates at a sufficiently elevated temperature, simply because it has a still higher boiling point.

The fact that sulphuric acid has great power to combine with water, has also led to a misunderstanding as to its strength. In the presence of organic matter it causes hydrogen and oxygen to combine and form water, with which it then combines; in a word, it produces bad burns upon the body.

DISSOCIATION THE MEASURE OF AN ACID'S STRENGTH.

The conductivity method as a measure of dissociation is the best general method for determining the relative strengths of acids and bases. An acid is a compound which in the presence of a dissociating solvent yields hydrogen ions. The strength of an acid simply means the number of hydrogen ions present in a given volume of its solution, at a given concentration. To measure the strength of an acid, we must therefore simply measure the concentration of the hydrogen ions, and this is just what we do when we measure dissociation.

Potassium and sodium and the other alkali hydroxides are among the strongest bases; with the hydroxides of calcium, strontium and barium next in order. The strength of a base simply means the number of hydroxyl ions present in a given volume of a solution of a given concentration of the base. To determine the strengths of bases it is simply necessary to measure their dissociation, the strength being proportional to the dissociation.

The conductivity method of measuring dissociation is applicable to all electrolytes, acids, bases and salts. Among the acids we find all degrees of strength represented—from the strongest like hydrochloric, to the weak organic acids, such as carbonic, hydrocyanic, etc. Similarly, we have all degrees of strength represented among the bases.

The salts in aqueous solution are, in general, strongly dissociated compounds. The exceptions are the halogen salts of mercury, cadmium, and to some extent zinc.

The above definition of acids and bases applies to solutions of these substances, which is the condition under which they act chemically. When fused these substances conduct and are, therefore, somewhat dissociated.

NO SUBSTANCE IS ACID OR BASE UNTIL DISSOCIATED.

The above definition would, of necessity, lead to the conclusion that pure, homogeneous substances are neither acids nor bases, but become such only when dissolved in dissociating solvents. Pure, dry liquid hydrochloric acid has no trace of acid properties; it will not act upon metals and will not decompose carbonates. It will not even turn blue litmus red. Similarly, pure, dry sulphuric acid will not color blue litmus red.

Further, when an acid like hydrochloric is dissolved in a non-dissociating solvent like chloroform or benzene, it has no acid properties. These facts alone suffice to show the justification for the above definition of acid and base, and there are a large number of others which could be cited were it desirable, and did space permit.

RELATIVE DISSOCIATING POWERS OF DIFFERENT SOLVENTS.

It seems desirable to consider somewhat in detail the dissociating powers of solvents, on account of the importance of this property both for pure science and for the industries. We have seen that chemical reactions depend primarily upon ions. The dissociating powers of the solvents in which the electrolytes are dissolved is what gives us the ions. Consequently, the dissociating power of a solvent is what determines primarily the chemical behavior of substances dissolved in it.

Water is not only the best solvent known, but has a greater power to break molecules down into ions than any other common solvent. Its great solvent power and its great dissociating power make it the most important solvent, many times over, in all chemistry. Indeed, water is by far the most remarkable compound in all chemistry. It is formed by the union of the hydrogen ion with the hydroxyl ion. The hydrogen ion is the one that gives all acidity, and the hydroxyl the one that gives all basicity. These are not only the most important ions in all chemistry, but they are the ions that have the greatest velocities in solution.

Water with respect to its properties is, in general, an extreme substance. Take any given property. With respect to this it stands either at the top or at the bottom of the list of solvents, and usually at the top.

Again, take its property of expanding before freezing. If water contracted down to its freezing point, as most liquids do, the whole face of nature would be changed in one cold winter, at least in northern latitudes.

Concentrated nitric acid has considerable dissociating power, but can hardly be used as a general solvent. Sulphuric acid, concentrated, has also been shown to have a marked power of breaking molecules down into ions.

Among the common organic solvents methyl alcohol has the greatest dissociating power, in general, from one half to one third that of water.

Ethyl alcohol comes next with about one fourth the dissociating power of water. The higher isomeric alcohols have less dissociating power than the lower or simpler members of the series, and this is a general fact in any homologous series of compounds. The simpler members, or those containing the smallest number of carbon atoms, have greater power to form ions from molecules than the more complex members.

Acetone, which is a good solvent, has about one fifth

* Reproduced from *The Engineering and Mining Journal.*

† Professor of Physical Chemistry Johns Hopkins University, Baltimore, Md.

the dissociating power of water. It should be stated in connection with acetone, that in addition to its power to break molecules down into ions, it also has a marked power of forming molecular complexes from simple molecules dissolved in it. It has a great associating or polymerizing property, and this accounts for the abnormal results that are so often obtained in acetone solutions.

Formic acid, while not a common solvent, has high dissociating power. Indeed, it dissociates to about three-fourths the extent of water.

The remaining organic solvents have much less dissociating power than those mentioned above, and this accounts for the comparative chemical inactivity of solutions in these substances as solvents. The hydrocarbons and esters have about the least dissociation power of any known solvents, and solutions in these substances show little chemical activity.

The dissociating power of the different solvents shows why it is that we often have to be almost as careful about the solvent we use to get a certain result, as about the substance that we dissolve in the solvent.

AMPHOTERIC ELECTROLYTES.

We have spoken thus far of liquid solvents breaking molecules of acids, bases and salts down into an equivalent number of positively charged cations, and negatively charged anions. This would leave the impression that the kinds of ions into which an electrolyte would dissociate are fixed and determined by the nature of the electrolyte alone, and are independent of the surrounding conditions. This is not always true, and one exception, at least, must be discussed.

Take a compound like zinc hydroxide. In the presence of an acid it dissociates into zinc and hydroxyl ions, and as follows:

$$Zn(OH)_2 = \overset{++}{Zn}, \overset{-}{OH}, \overset{-}{OH}$$

It dissociates, under these conditions, just like any other base, and when treated with an acid the hydrogen ions of the acid combine with the hydroxyl ions of the base, and when the solution is evaporated a salt is formed. It should be stated that a salt is not formed when a dilute solution of an acid reacts with a dilute solution of a base, unless the salt is insoluble in the solvent in question. This will be seen to be the case when we recall that a dilute solution of almost any salt is completely dissociated into its ions. We get the salt only when we evaporate the solution, and drive off water which breaks the molecules down into charged parts or ions.

When zinc hydroxide is treated with a strong base, say sodium hydroxide, it no longer dissociates as a base, but as an acid, and in the following sense:

$$Zn(OH)_2 = \overset{+}{H}, \overset{+}{H}, \overset{=}{ZnO_2}$$

The hydrogen ions from the zinc hydroxide combine with the hydroxyl ions from the sodium hydroxide, and form water and sodium zincate.

There are a number of well known substances which behave like zinc hydroxide, dissociating as a base in the presence of an acid, and as an acid in the presence of a base. Such substances are termed amphoteric electrolytes. Aluminium hydroxide is another example in general chemistry, and there are many examples among the compounds of carbon.

The above discussion of amphoteric electrolytes brings out a principle which is fundamental and apparently general. Zinc hydroxide in the presence of an acid yields hydroxyl ions, while when a base is added to it, i. e. when hydroxyl ions are added to it, it no longer dissociates into hydroxyl ions. This kind of dissociation is suppressed, and the zinc hydroxide dissociates in an entirely different way, giving no hydroxyl ions, but only hydrogen ions. The dissociation into hydroxyl ions is entirely suppressed by the addition of a large number of hydroxyl ions from the dissociated sodium hydroxide. The general principle illustrated by the manner of dissociation of the zinc hydroxide is that *the presence of a common ion drives back the dissociation which yields that ion.*

If hydrochloric acid is added to a solution of sodium chloride, the dissociation of the latter is driven back, and driven back according to a well known law; the amount depending on the amount of hydrochloric acid added. This driving back of the dissociation is due to the presence of the common ion—chlorine. Indeed, the best method of purifying sodium chloride is based upon this principle. Prepare a saturated solution of sodium chloride and conduct in a stream of hydrochloric acid gas. The dissociation of the salt is driven back, i. e. more molecules are formed, but the solution is already saturated with respect to molecules of sodium chloride, and as more molecules are formed they are precipitated. A repetition of the above method of precipitating sodium chloride will give the fairly pure salt from a complex admixture with other things.

The above principle of the presence of a common ion driving back the dissociation which yields that ion, is almost as important for the industries as for pure science, as a little thought on this problem, in the light of the above facts will show.

THE ACTION OF PRIMARY CELLS.

The primary cell was discovered by Volta, more than a century ago, but it is only comparatively recently that we have come, even in part, to understand its action. So true is this that it is only for a few decades that we have known what are the chief sources of the electromotive force in such cells. Take as a type of the primary cell the Daniell battery, which consists of one electrode of copper immersed in a solution of copper sulphate, and the other electrode of zinc surrounded by a solution of zinc sulphate. The copper is the positive pole and copper separates from the solution upon the copper electrode. The zinc electrode dissolves, zinc passing into solution as zinc sulphate, or zinc ions pass into the solution.

There are three possible sources of electromotive force in such a system: At the surface of contact of the zinc with the zinc salt; at the surface of contact of the copper with the copper salt, and at the surface of contact of the two electrolytes with one another. Which is the chief source of the electromotive force of the cell?

The solution of the problem of the primary cell we owe largely to W. Nernst, now of the University of Berlin, utilizing the gas laws as applied to the osmotic pressure of solutions by Van't Hoff, and the theory of electrolytic dissociation of Arrhenius.

Given a metal, say zinc, surrounded by one of its own salts, say zinc sulphate. At the surface of the metal there exists a tension, known as solution tension, which tends to drive atoms off the bar of metal into solution as ions. The metal atoms become ions by taking a positive charge of electricity from the remaining metal bar, which, consequently, becomes charged negatively.

OSMOTIC PRESSURE OPPOSES SOLUTION TENSION.

Opposing the action of solution tension which drives atoms of the metal into solution, is the osmotic pressure of the metal ions in solution, which acts so as to drive metal ions out of the solution onto the bar. If these cations were driven onto the bar of metal, they would give up their charge to the bar, and the electrode would become charged positively.

What happens in any case depends upon which of these opposing forces is the greater. In the case of zinc the solution tension of the metal is always greater than the osmotic pressure of the zinc ions in any possible solution of any zinc salt. Consequently, a bar of zinc is always negatively charged whenever it is dipped into any solution of a zinc salt.

With copper exactly the reverse is true. The osmotic pressure of the copper ions in a solution of almost any concentration of a copper salt is greater than the solution tension of copper; which is infinitesimal. Consequently, when a copper bar is plunged into a solution of copper salt, the bar becomes charged positively relative to the solution.

When the copper and zinc are connected metallically, and the copper and zinc salts by means of a siphon, we have a Daniell cell, and we can now see just how this works. Zinc having a high solution tension passes into solution, and copper having such a low solution tension separates from the solution of the copper salt onto the bar. Copper, receiving the copper ions, is therefore the positive pole, and zinc, losing positive ions to the solution, is therefore the negative pole. The current flows on the outside from the copper to the zinc, and on the inside from the zinc to the copper.

E. M. F. OF PRIMARY CELLS CAN BE CALCULATED.

Nernst has worked out a method for calculating the electromotive force of such cells. The method involves essentially the solution tensions of the metals used as electrodes and the osmotic pressures of the cations of the electrolytes.

This method of dealing with the primary cell involves the existence of the force which has been called solution tension of the metals. It should be stated that the existence of this force has been demonstrated beyond reasonable question by experiments that have no direct connection with the primary cell as such.

The method worked out by Nernst for calculating the electromotive force of primary cells of the Daniell and several other types, cannot be more than mentioned in the narrow scope of this paper. Those interested will find it discussed in detail in my "Elements of Physical Chemistry," fourth edition, pp. 442-492.

Suffice it to say that the electromotive force calculated for such cells agrees with the results of direct measurements, otherwise the method would not be discussed here. The result is that the chief source of the electromotive force in primary cells is at the surface of contact of the electrodes with the electrolytes. There is a small difference of potential or electromotive force at the surface of contact of the two electrolytes with one another, and another small difference of potential where the two metal electrodes come together directly or indirectly; but these are both so small that, under ordinary conditions, they are comparatively speaking almost negligible.

SOURCE OF ENERGY IN THE PRIMARY CELL.

The question that still remains is what is the source of the electrical energy that is produced say in a Daniell cell? We start with zinc, copper, zinc sulphate and copper sulphate. After the battery has acted for a time we have less zinc and more copper than at the beginning. The source of the electrical energy that appears is the intrinsic energy of the zinc that has disappeared, over and above the intrinsic energy of the copper that has been formed during the action of the cell.

Certain forms of primary cells are simply machines for converting heat into electricity—they cool themselves as they act; but unfortunately no such cell thus far discovered has the power to convert any large amount of heat directly into electricity. If it did, it would be a matter of tremendous technical importance. To convert large amounts of heat directly into electricity would be almost as important as to convert amounts of intrinsic energy directly into electricity, since there is no difficulty in converting intrinsic energy directly into heat in any amount desired. The solution of the problem of converting heat directly, quantitatively and in large quantity into electricity remains for the future, and its solution will be nothing less than epoch-making for the industries.

The Daniell cell can convert only a relatively small amount of intrinsic energy into electricity, and this not very economically.

THE SECONDARY CELL OR STORAGE BATTERY.

There have been several forms of storage batteries devised. The best known of these is the ordinary lead cell. While some of the details of its action are not fully understood, yet the general principles which it illustrates are perfectly clear.

Such a cell consists of one plate of lead dioxide, the other of lead, and the electrolyte sulphuric acid of a certain definite concentration (sp. gr. 1.2). When an electric current is passed into and through such a cell, lead dioxide is deposited upon the plate where the current enters and lead upon the other plate. Lead dioxide represents lead in the quadrivalent condition—each lead ion has four charges upon it, while lead in the form of sulphate has only two charges upon it. The action of the charging current is then to raise the valence of the lead from two to four—to raise the intrinsic energy of the lead.

When the accumulator discharges, exactly the reverse takes place. The lead dioxide and also some of the lead pass into solution in the sulphuric acid as lead sulphate.

The charging current, then, raises the intrinsic energy of the lead from the bivalent to the tetravalent condition; while in discharging, the intrinsic energy of the lead is lowered from the tetravalent to the bivalent condition. In charging a storage battery we are converting electrical energy into intrinsic. In discharging we are converting intrinsic energy into electrical.

CHEMICAL ACTION AT A DISTANCE.

The idea has long prevailed that in order to have chemical action we must have mechanical contact. We shall now see that this idea is erroneous, and not only shall we learn that we can have chemical action between two things that do not touch, but from what has already been said in reference to the solution tension of metals we can easily understand what takes place.

Take a bar of pure zinc and dip it into dilute sulphur acid. If the zinc is sufficiently pure it will dissolve very slowly, and hydrogen will escape very slowly from the solution of the acid.

Wrap a piece of platinum wire around the bar of pure zinc and to the other end of the wire attach a piece of platinum foil. Let the bar of zinc pass through a cork which fits into the top of a glass tube three or four inches long. Close the bottom of the glass tube with a piece of vegetable parchment. Fill the glass tube now containing the bar of zinc with a solution of some soluble sulphate—say ammonium sulphate—and plunge it into a large beaker also filled with a strong solution of ammonium sulphate.

The platinum wire connected with the bar of zinc above the glass tube is led down into the beaker, and the platinum foil attached to the end of the platinum wire allowed to rest on the bottom of the beaker. If sulphuric acid is now added by means of a pipette to the platinum foil, hydrogen will escape rapidly not from the zinc but from the platinum, and zinc will dissolve.

PROOF THAT ACTION TAKES PLACE AT A DISTANCE.

The zinc thus really dissolves in sulphuric acid which does not touch it, but which is contained in another vessel. The object of the vegetable parchment over the bottom of the glass tube is to keep the sulphuric acid in the beaker away from the zinc, at least for a time. That the sulphuric acid in the outer vessel does not at first touch the zinc, although hydrogen is given off at once from the platinum foil, can be very readily proved by introducing some blue litmus paper into the neutral solution of sulphate around the bar of zinc. The zinc not only dissolves in sulphuric acid which does not touch it, but dissolves much more rapidly than if the acid were added directly to the metal.

What is the explanation of these rather remarkable results? In the first place, why does not pure zinc dissolve in acids when, as we have seen, zinc has a very high solution tension? The enormous solution tension of zinc is the very cause of zinc not dissolving in acids. The solution

tension drives zinc ions into the solution with an enormous force. But in order that a metal should dissolve in an acid, the hydrogen cations of the acid must give up their charge to something and escape. If the metal has a very high solution tension tending to push its own ions into solution, the hydrogen ions of the acid cannot get up to it; and if the hydrogen cannot come up to and touch the zinc, they cannot discharge, since there is nothing to which they can give up their charge. Consequently, the zinc ions cannot enter the solution in any appreciable quantity; it being a fundamental condition of equilibrium in solution that there cannot be present in it any appreciable excess of cations or of anions.

MECHANICS OF ACTION AT A DISTANCE.

Platinum is a metal with small solution tension. The hydrogen ions can easily come up to and give up their charges to the platinum. They do so and escape from the solution as hydrogen gas. The charge is conducted along the platinum wire to the zinc. The zinc atoms take up the charge and pass into solution as ions, pairing themselves against the SO_4 ions which were initially paired off against the hydrogen ions of the acid—the hydrogen ions in question having lost their charge escape as hydrogen gas.

Pure zinc, then, does not dissolve in acids not because it has not a powerful solution tension, but because the hydrogen ions of the acid cannot come up to it and give up their charge and escape. We render zinc "impure" and make it dissolve by bringing it in contact with some metal with a low solution tension, such as platinum, copper and the like, and for the reason pointed out above.

Another experiment illustrating even more strikingly "chemical action at a distance," is the following. Place a solution of ferrous chloride in one beaker and a solution of potassium chloride in another beaker and connect the two beakers with a siphon filled with the neutral potassium chloride. Dip a platinum electrode into each beaker and connect the two electrodes externally through a galvanometer. Under these conditions nothing will happen.

IRON OXIDIZED BY DISTANT CHLORINE.

Now conduct a current of chlorine gas into the neutral solution of potassium chloride, and the ferrous chloride in the other beaker will be gradually oxidized to ferric chloride. The ferrous chloride in one vessel is thus oxidized by chlorine which is in an entirely different vessel, and which may be separated from the ferrous salt by a very considerable distance. This is an ideal demonstration of chemical action taking place between two substances that are some distances apart.

What is the explanation of the above experiment? The chlorine coming in contact with the platinum electrode takes up negative charges, or electrons as they are called, from it. This electrode, having lost negative charges, is charged positively, and a current flows from this electrode over to the other electrode which is surrounded by the ferrous salt. The ferrous ions are ions of iron that have each two positive charges upon them. The iron ion, however, can carry three positive charges, as in the ferric condition. The bivalent ferrous iron takes a positive charge from the electrode immersed in it, passing over into the ferric ion, which carries three electrical charges. The iron is thus oxidized from the ferrous to the ferric condition, i. e. its valence is raised by chlorine which never comes near it.

This experiment is of great importance in connection with the whole subject of chemical valence. The valence of the iron is raised from the condition of two to three, and how? By adding an electrical charge to it, by adding one unit of electricity to it, and by doing nothing else. This alone would show the connection between valence and the electrical charges carried by the ions. This same fact is, however, emphaszied over and over again in the treatment of valence from the only standpoint that is worth calling scientific, viz. Faraday's Law. It would lead us much too far to discuss this subject here. For the application of this conception to general chemistry, see my "Principles of Inorganic Chemistry" and "Elements of Inorganic Chemistry," published by the Macmillans, New York.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

Holland and the Diffusion of Knowledge

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

I have read with much interest the article "Diffusion of Education and Knowledge," in No. 1932 of the SUPPLEMENT, but I am sorry to say that I do not agree with the conclusions of the author.

He takes as a basis for his research the politic-geographic frontiers of the different countries, instead of their philological ones. This leads him, for instance, to overrate the value of the Swiss and to do injustice to the other small countries, as Denmark, The Netherlands, and others. He also fails to take into account the high percentage of Dutch scientists, winners of the Nobel prize, which may be accepted as a demonstration of the level of general knowledge of the Dutch. It is a fact that the Dutch language does not reach over the frontiers, which compels the civilized inhabitants to learn four languages. Dutch books are only published and sold within our own boundaries. In Belgium people only read French novels, and the trade with the colonies is insignificant; while the Dutch people are good buyers of German, English and French books. The Netherlands, with their six millions Dutch-speaking inhabitants, buy more French works than Belgium with a population of seven millions, of whom three millions are French-speaking; and the lists of our circulating libraries contain more English, German and French titles of books than Dutch ones. Meanwhile, this important importation of foreign works is an impediment to the development of our own book market. Moreover, our most eminent scientific authors, such as Zeeman, de Vries, Lorentz and others, often publish their best works in the English, German or French language. Quite different are the conditions for the Swiss. These are, in point of philology, members of the three great nations, German, French or Italian, and as such their authors command an immeasurable field for exploitation.

Amsterdam. R. A. OOSTERHOUT.

A Mathematical Nut for the Year 1913

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

The following is a solution of the problem set by Mr. S. W. Balch in the issue of February 8th, 1913:

$$\text{Let } (a-bi)\,(c+di)=1913$$

$$\left.\begin{aligned} ac+bd&=1913\\ ad-bc&=0\end{aligned}\right\}$$

$$\text{or}\quad ac+bd=1913$$

$$\left(\frac{d}{c}\right)-\left(\frac{b}{a}\right)=0$$

$$\text{Let}\quad a=c=x$$

$$b=d=y$$

$$\begin{aligned} x^2+y^2&=1913\\ &=64+1849\\ &=8^2+43^2\end{aligned}$$

$$x=8$$

$$y=43$$

Check

$$\begin{aligned}(8-43i)\,(8+43i)&=8^2+43^2+(8\times43-43\times8)i\\ &=64+1849\\ &=1913\end{aligned}$$

East Orange, N. J. E. D. MOLINA.

Procryptic Coloration a Protection Against Lions

By R. I. Pocock

THERE has been some interesting correspondence in recent numbers of *The Field* on the question of the procryptic coloration of big game, some writers taking one side and some another in the controversy. Now although there is a certain amount of evidence, scattered through sporting literature, showing that some species of African antelopes and zebras are hard for human beings to detect in particular surroundings, there is, so far as I am aware, scarcely any testimony, based upon observation in the jungle, to prove that the sight of predatory carnivora is baffled in the same way by color assimilation.

This question has such an important bearing on the theory of the evolution, through natural selection, of obliterative coloration that I venture to repeat the following story, told by Mr. F. C. Selous (*The Field*, January 18th, p. 141), which I hold to be one of the most valuable contributions to the subject ever published, and worthy, as such, of being made known to a much wider circle of zoologists than is comprised by readers of *The Field*. Mr. Selous says:

"I once wounded one (a lion)—a very savage lion, I think—which at once came round to look for me. I was sitting on the side of a large ant-heap, and no doubt my bare sunburnt arms and legs, and the dirty old shirt and towel in which I was dressed, assimilated well with the color of my surroundings, for although the lion came and looked straight at me, he could not make me out. I had not had time to reload my single-barreled rifle, but had a cartridge in my right hand ready to slip into the open chamber if the lion charged. But when he came toward me and then stood looking at me, I did not make the slightest movement, and he could not make me out, and presently turned and looked the other way. . . . I am perfectly certain that had I made the slightest movement . . . this lion would have charged."

Mr. Selous is a staunch opponent of the theory of the survival value of obliterative coloration in big game, and his experience, above recounted, gains force from the fact that it was described in an article in which he was combating the double claim that the equine and most of the ruminant mammals of Africa are procryptically colored and are benefited thereby. But we shall probably have to wait many years before we get a more cogent piece of evidence in favor of the value to antelopes and other game of a combination of assimilative patterns with stillness.—*Nature.*

The Effect of Distilled Water on the Animal Economy

MOUNTAIN climbers are warned against drinking water from melted snow or glaciers. Perhaps the basis of this precaution is to be found in the observation made by Dr. R. Oehler, that mice fed with distilled water were found to excrete red blood pigment, owing to the disturbance of the osmotic balance of the blood, which causes the red pigment to diffuse through the walls of the blood corpuscles into the blood serum.

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